CONTEXT-SENSITIVE DECISION SUPPORT SYSTEMS: SUPPLEMENT PAPERS

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Abstract:
These Proceedings contains a complement of papers to selected contributions to the conference on *Context sensitive Decision Support Systems*, held in Bled, Slovenia, in July 1998. The conference was organised by the International Federation of Information Processing's Working Group 8.3 on Decision Support Systems, the Faculty of Organizational Sciences at the University of Maribor, Slovenjia, and the Slovene Society Informatika. The Programme Committee for the Conference (George Widmeyer, University of Michigan Business School, USA, chair; Dina Berkeley, London School of Economics, UK; Patrick Brézillon, Paris 6, France; Vladislav Rajkovic, University of Maribor, Slovenia) served also as the editors of a book published by Chapman & Hall. Vladislav Rajkovic was also the chairperson of the organising committee.

Résumé:
Ces actes contiennent un complément de papiers contributions sélectionnées pour la conférence sur les Systèmes d'Aide à la Décision Basé sur le Contexte qui s'est tenue à Bled (Slovénie) en juillet 1998. La conférence était organisée par la *International Federation of Information Processing's Working Group 8.3 on Decision Support Systems*, la Faculté des Sciences de l'Organisation de l'Université de Maribor (Slovénie) et la Société Slovène d'Informatique. Les membres du Comité de Programme de cette conférence (George Widmeyer, Université de *Michigan Business School*, USA, chair; Dina Berkeley, *London School of Economics*, UK; Patrick Brézillon, Université Paris 6, France; Vladislav Rajkovic, *University of Maribor*, Slovenia) sont aussi les éditeurs d'un livre publié chez Chapman & Hall. Vladislav Rajkovic était le responsable du Comité d'Organisation.

PREFACE

These Proceedings presents a complement of papers to selected contributions to the conference on *Context sensitive Decision Support Systems*, held in Bled, Slovenia, in July 1998. The conference was organised by the International Federation of Information Processing's Working Group 8.3 on Decision Support Systems, the Faculty of Organizational Sciences at the University of Maribor, Slovenjia, and the Slovene Society Informatika. The Programme Committee for the Conference (George Widmeyer, University of Michigan Business School, USA, chair; Dina Berkeley, London School of Economics, UK; Patrick Brézillon, Paris 6, France; Vladislav Rajkovic, University of Maribor, Slovenia) served also as the editors of a book published by Chapman & Hall. Vladislav Rajkovic was also the chairperson of the organising committee. Each contribution for the book and as supplement paper was selected by the editors after peer review and was developed by its authors specifically for inclusion in the volumes.

Working group 8.3 was formally established in 1981 on the recommendation of IFIP's Technical Committee on Information Systems (TC8). The scope of the working group covers:

> "Development of approaches for applying information systems technology to increase the effectiveness of decision makers in situations where the computer system can support and enhance human judgment in the performance of tasks that have elements that cannot be specified in advance."

The principal aim of the working group is:

> "To improve ways of synthesising and applying relevant work from reference disciplines to practical implementations of systems that enhance decision support capability."

The group holds working conferences like this bi-annually. We are indebted to a variety of academic and industrial sponsors who contribute towards the conference expenses. In particular, for this 1998 conference, we are thankful to: the Ministry of Science and Technology of the Republic of Slovenija,, Jozef Stefan Institute, SAS Institute Slovenija, Mercator, d.d. and Temida, d.o.o.in Slovenija, and Entreprise LSE (ELSE) of the London School of Economics and Political Science, London, UK

SUMMARY

DOES THE LIBERTY OF CHOOSING VISUAL DISPLAY MODES AFFECT THE QUALITY AND TIME OF DECISION MAKINGS?

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Abstract

Building an effective and adaptable decision support system (DSS) has long been the dream of both practitioners and researchers. There are numerous factors which affect the success of DSSs: one of them is having the right context. The right context could mean the designers of DSSs have taken tasks, time, individual differences, and organisational and cultural differences into considerations. In this study, the researchers attempted to examine the context in the area of visual displays and the liberty of choosing and changing them. One hundred and sixty six participants used a computer-based decision support system to find the optimal number of employees to be employed in a canteen to maximise profit. Unlike most studies, participants in this study had the liberty to choose and change the visual display modes, namely, dynamic, static and text whenever they liked. This paper discusses the process of changing display modes more than the effect of visual display modes to the solution of the problem alone.

Keywords

Dynamic visual displays, visual interactive modelling, decision quality, decision time, graphs.

1. INTRODUCTION

Decision making is a complex process which is affected by various factors. A Decision Support System (DSS) is meant to aid decision makers to make better decisions when having to solve semi-structured or ill-structured problems. The right context has been one of the main concerns in building an effective DSS as many authors (such as Jarvenpaa and Dickson, 1988; Liang 1986, Vessey, 1994) attempted to discover the factors affecting the success of DSSs. However, none of them have identified the key element as contexts such as cultural, organisational, tasks and individual differences could interact and change over time. The authors do not regard contexts as restricted to the presentation in words but also include other modes of presentation such as static and dynamic visual displays and the liberty of choosing them. The saying goes "a picture is worth a thousand words". According to Liang (1986), the representation format is the most critical factor affecting a user's attitude for any decision support system (DSS) to be implemented successfully. When there is a large amount of data, a manager must reduce the volume to a manageable size and focus on those data points that are crucial. Graphics fit in this requirement as they help managers to "visualise" relationships and to summarise data.

Various disciplines, such as psychology and statistics, have hosted a considerable amount of research work into graphical displays. Information systems (IS) researchers started to do research in this area in the 1970s (DeSanctis 1984). "Primitive" graphs are static, representative graphs include bar charts and pie charts, whilst the "advanced" graphics involve dynamic, iconic and model running graphs. Static graphs summarise and display data from a mathematical model whilst dynamic visual displays evolve over time during processing. The evolution is represented by "flicker" or by animation. The flicker technique uses programmed colour changes to depict changing states of the system. The animation effect is created by having the images or icons that represent moving objects move around on the display screen (Bell et al. 1984).

The earlier research in IS mainly concerned the effectiveness of tables and graphs. Some studies found that graphical representations were better than tables (Benbasat and Schroeder 1977, Tullis 1981) while others found the opposite (Grace 1966, Remus 1984, Wainer and Reiser 1976). Some studies showed that there was no difference or that results were mixed (DeSanctis 1984, Dickson et al. 1986, Ives 1982, Lucas 1981, Lucas and Neilson 1980). However, Jarvenpaa and Dickson (1989) proposed that graphs were more effective for summarising large volumes of data and good for tasks which required identification of patterns such as forecasting and trend analysis. Various congruencies between display and task affect both decision time and quality (Bettman & Zins 1979, Jarvenpaa 1989).

Research has recently been conducted in the area of dynamic graphics. Some used object-oriented software (Angehrn and Lüthi, 1990; Pracht and Courtney, 1990) to model dynamic systems whilst others used Visual Interactive Modelling (VIM) tools. VIM is not only dynamic, but also allows users to intervene in the visual displays and see a new set of results after intervening. In fact, VIM has been popular in the field of operational research for more than twenty years but only in the past ten years have DSS researchers used this technique to present data. Bell (1988), Belton and Elder (1994), Hurrion (1985), Miller (1969) and Smith and Platt (1987) strongly support the role of dynamic graphics in supporting decision making.

Vessey (1991,1994) summed up the results of published studies on the performance of graphical and tabular representations in decision making. Most of the empirical results could be explained by the theory of "cognitive fit" which matches the type of tasks with information presentation. Vessey suggests that the process or strategy problem solvers used could be classified as perceptual and analytical. The processes were the crucial elements of cognitive fit since they provided the link between representation and task. When there is a fit between the representation, process and task type, it would lead to quicker and more accurate problem solving. Lastly, she concluded that decision makers were willing to forego some accuracy for a substantial reduction in effort (Vessey 1994).

2. RESEARCH OBJECTIVES

Despite the vast interest in finding the most appropriate visual display methods in DSS, there has not been any conclusive proof of whether the presentation format, the use of colour, and the impact of different graphic capabilities influence decision making. Keen and Scott Morton (1978) argued that the success of a decision aid was ultimately measured in terms of its ability to improve decision quality or speed. The advantages of using dynamic graphs were mainly gathered by survey (such as Kirkpatrick and Bell 1989) and case studies (such as Chau and Bell, 1994). Little experimental research has been done on dynamic visual displays. In this respect, the researchers were interested to find out if dynamic visual display modes improve the quality of decisions.

Funk and Miller (1997) suggested that one of the three elements to support effective context sensitive interfaces was the ability to modify the control and display configuration accordingly. However, most of the participants were randomly assigned to different visual displays in experimental research, for example, Benbasat and Dexter (1985), Chau (1995), Lucas, (1981), O'Keefe and Pitt (1991). It was neither clear if a user had visual display mode preferences to aid the understanding of a problem, nor evident whether the liberty of changing display modes affected decisions or not.

Since timeliness is crucial for decision making in a fast paced business world, shorter decision making time was also thought to be an important factor for using decision support systems (Benbasat and Dexter, 1981). Therefore, the researchers were interested to know if:

1. Participants had any preferences of visual display modes to aid the understanding of a problem.
2. There is any difference in terms of the quality of decision making and decision making time when participants use a particular type of visual display which could be text, static or dynamic.
3. There is any difference in terms of the quality of decision making and decision making time when participants use one or more visual display modes.

3. EXPERIMENTAL DESIGN

The Experimental Task

The participants were asked to solve a fictitious case of a canteen operating in a university. They were asked to decide on the optimal number of servers serving at the food counter, the drink counter and the cash register so as to maximise net profit per unit time. Assuming that there was no rental cost nor other costs incurred, the net profit would be gross profit minus pay for all servers (servers at drink, food counters and cash register). The arrival rate of students/staff during lunch time was between 3 to 7 per minute. The customers would not enter the canteen when any counter/cash register had 30 customers queuing up.

The average serving time at the food counter was 1.2 minutes, at the drink counter was 0.7 minutes whilst at the cash register was 1.5 minutes. In general, about half of the customers would request drinks. On average, the canteen could make a gross profit of $5 per customer regardless of whether the customers had ordered drinks or not. The canteen could only make a profit when the customers paid at the cash register. The servers who worked at the canteen were paid hourly. The servers at the food and drink counters earned $20 per hour and the cashiers earned $25 per hour.

Table 1 - Education Level of Participants

Highest Education Level	*Number*	*Percentage*
A_Level	111	67.3%
Diploma	6	3.6%
Bachelor	34	20.6%
Post_Dip	4	2.4%
Masters	9	5.5%
Ph.D.	1	0.6%
Total:	165	100.0%

Experimental Procedure
The data was collected over a period of 5 months, from February to June 1997. Participants were students recruited in the United Kingdom and in Hong Kong from three different tertiary institutions. A total of 166 students, 52 (31.3%) females and 114 (68.7%) males, participated in the experiments. 61.4% of the participants were studying in HK and 38.6% were studying in the UK. The level they studied ranged from certificate course to Ph.D. The majority of participants were undergraduate/certificate full-time students whose highest educational level was A-Level which is shown in Table 1 below (one did not answer this question). Basically the participants were either studying a module or a program in the business school or studying in a teacher training program.
The Experiment
Participants were given a case, instructions for operating the software, a recommendation sheet and scrap paper in a computer laboratory. They were asked to solve a queuing problem of a canteen as described above. They were asked to read the case before using the software. After 5 minutes, the participants were shown how to use a computerised decision support system. Pencils, scrap paper and calculators were allowed to perform any necessary analysis. The participants were told that they were expected to finish the experiment within about 45 minutes but they could leave at any time they felt like.

The participants were asked to give some demographic information like their sex, age and their educational level after logging in to the system. They were also asked to choose their preferences of visual displays, i.e. text, static or dynamic displays (appearing in that order in the list box), to input the number of cashiers and servers employed in the drink counter and food counter in the canteen in order to maximise profit in the second screen. The participants had full liberty to switch between different visual display modes so as to experience the different output formats. The output formats for the three display modes were almost the same. The difference between text and static display modes was that the static one had iconic representations beside the counters' names. The difference between static and dynamic visual display modes were the movements of "faces" in the queues.

When the participants felt they had found the optimal number of servers, they could put down their recommendations on a recommendation sheet and leave. The participants were reminded about the time after 40 minutes but they were not compelled to follow the time constraints if the laboratory was available. They would be thanked and reminded not to disclose any information to other fellow students. The case, instructions for operating the software, recommendation sheets and scrap papers were collected after the experiment.

4. RESULT FINDINGS

The Decision Process
As shown in Table 2, most of the participants (74.1%) chose dynamic visual display modes as their preferred visual display modes at the start followed by text and static visual display mode. About half of the participants (56.6%) were comfortable with their first chosen visual display modes and continued using them for the whole experiment. Figure 1 shows that fewer and fewer participants tried out different visual display modes as time went by. 72.8% of the participants did not make changes after changing to another mode of visual displays once and 86.8% did not change after changing twice. All except 3 participants who tried out all three visual display modes and settled on their "preferred" visual display modes. One participant settled after trying different visual displays mode for 4 times and settled on the fifth try. The other two settled after trying out different visual display modes for 5 times and settled on the sixth try.

Figure 2 shows how the percentage of participants who used dynamic visual displays rose gradually. Since the dynamic visual display mode was the most chosen first visual display mode, the number of participants who chose dynamic visual display mode dropped naturally as they tried out other visual display modes later. 62.0 % of the participants used dynamic visual displays as their second chosen visual display mode, 67.5% as their third chosen visual display mode, and 75.3% as their fourth chosen visual display mode. Figure 3 shows a consistent change from other display modes to dynamic visual display mode. It was interesting to note that 2 participants finally chose dynamic visual display after changing display mode for 5 times. Table 3 shows that 10 out of 18 participants who chose static and text visual displays respectively changed to dynamic visual displays as their second chosen visual display mode. Incidentally, the percentage of using dynamic visual displays as the final visual displays (75.3%) were almost the same as initially (74.1%).

Table 2 - 1st Chosen Visual Display Modes

Mode of Display	*Number*	*Percentage*
Dynamic	123	74.1%
Static	18	10.8%
Text	25	15.1%
Total	166	100.0%

Figure 1 - The Trend of Not Changing Visual Displays Mode

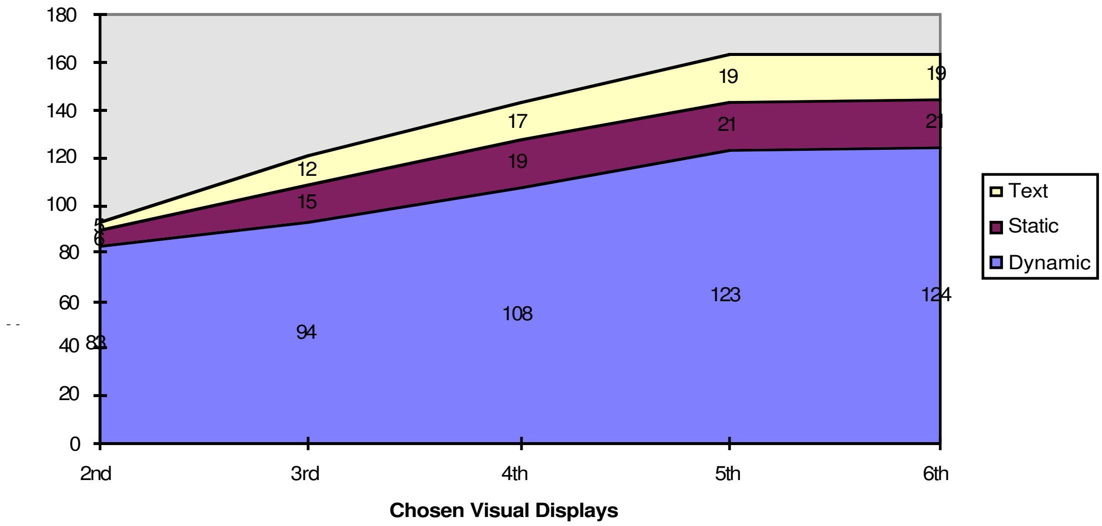

Table 2 shows static was the least favourite visual display at the beginning. 15.1% of the participants chose text at the start versus 10.8% chose static. Static became more favourable than text visual displays from the second try onwards even though the differences were not great (Figure 2). Table 3 shows about one third of the participants who chose static were happy with their first chosen visual displays. Most of those who made changes tried dynamic visual display as their second visual display mode. This phenomenon remained true for other attempts (Table 4 and Table 5). The number of participants selected static visual displays initially (10.8%) were slightly lower than using it as the final visual display mode (13.3%).

The participants who chose text visual display mode appeared to be the least satisfied as only 5 (20%) participants remained using text display for the whole experiment (Table 3). Half of those who changed to another visual displays chose dynamic whereas the other half chose static as their second try. However, for those who had switched to using text mode as their third choice, more tried static visual display mode. This phenomenon reversed almost to an extreme as only one participant changed from text mode to static mode but 7 changed to dynamic visual display mode as their final chosen visual display mode (Table 5). Contrary to some researchers' beliefs that participants would shift to text mode or turned off the dynamic visual displays once they had grasped the information (Bell, 1989; Bookbinder and Kotwa, 1987; Ives 1982), the number of participants who selected text visual displays at the start (15.1%) was in fact slightly higher than those selecting it as the final visual display mode (11.4%).

Figure 2 - The Trend of Visual Display Modes Chosen

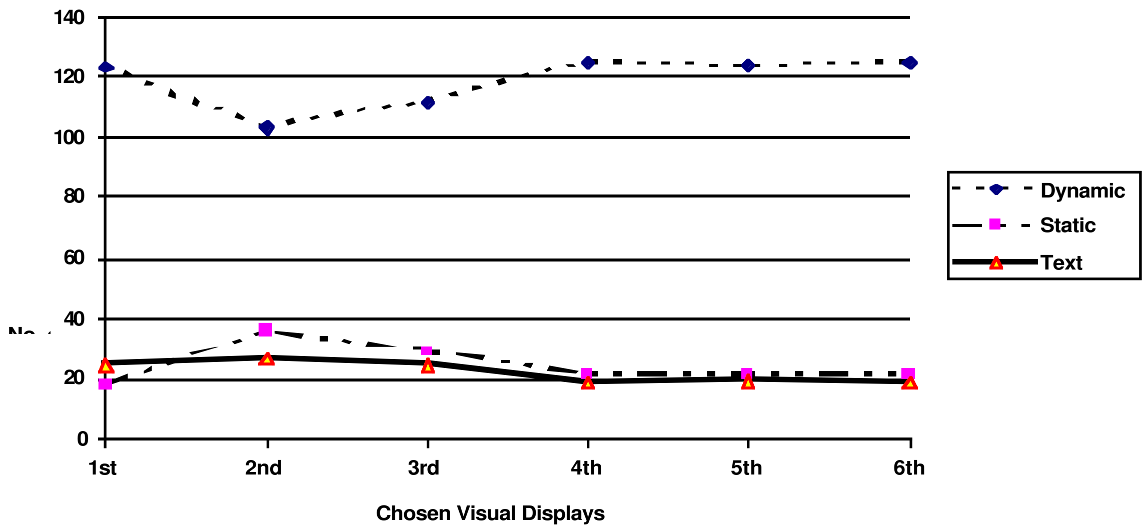

Figure 3 - Participants Using Dynamic Visual Displays Mode

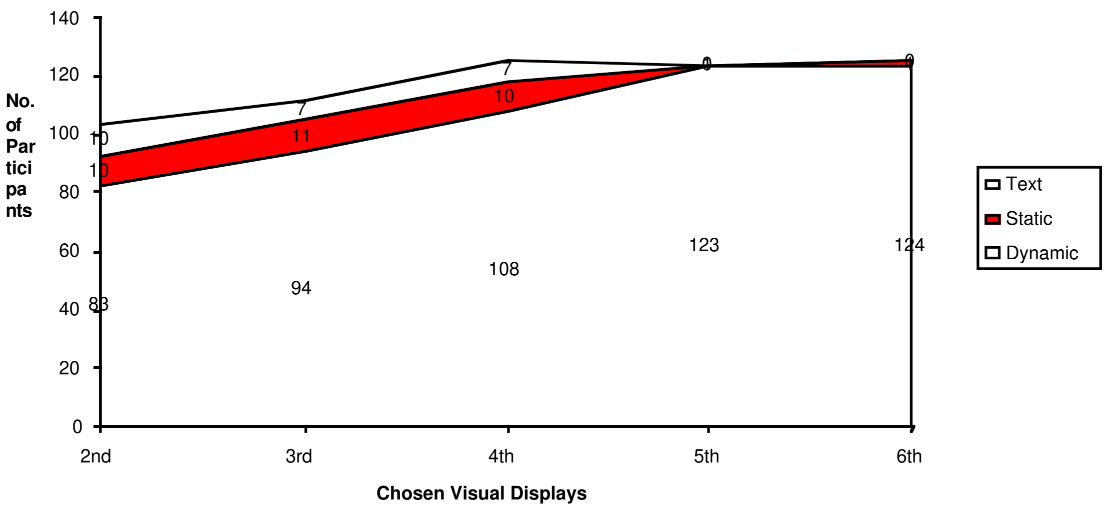

Table 3 - 2nd Chosen Visual Display Modes

From\To	*Dynamic*	*Static*	*Text*	*Total*
Dynamic	83 (67.4%) No Change	20 (16.3%)	20 (16.3%)	123
Static	10 (55.6%)	6 (33.3%) No Change	2 (11.1%)	18
Text	10 (40.0%)	10 (40.0%)	5 (20.0%) No Change	25

Table 4 - 3rd Chosen Visual Display Modes

From\To	*Dynamic Total*	*Static*	*Text*	
Dynamic	94 (91.2%) No Change	5 (4.9%)	4 (3.9%)	103
Static	12 (33.3%)	15 (41.7%) No Change	9 (25.0%)	36
Text	6 (22.2%)	9 (33.3%)	12 (44.5%) No Change	27

Table 5 - 4th Chosen Visual Display Mode

From\To	*Dynamic Total*	*Static*	*Text*	
Dynamic	108 (96.4%) No Change	2 (1.8%)	2 (1.8%)	112
Static	10 (34.5%)	19 (65.5%) No Change	0 (0.0%)	29
Text	7 (28.0%)	1 (4.0%)	17 (68.0%) No Change	25

As more than half of the participants changed the visual display modes more than once, the longest time the participants used a particular visual display mode was considered as the preferred visual display mode. Table 6 shows that more than 86% of the participants preferred dynamic visual displays. This finding suggests that participants had a preference for visual displays to aid the understanding of the problem and therefore the first research question that there is no preference of visual displays to aid the understanding of the problem is not supported.

Decision Quality and Decision Time

In this study, profit earned per unit time was used as a surrogate of decision quality since this is the objective of the problem. Table 6 shows the decision quality (profit/time) for dynamic visual displays was better than text and static visual displays. Due to the exceedingly large proportion of participants using dynamic visual displays, quantitative statistics might not be very appropriate. Nevertheless, ANOVA was used to analyse but there was no statistical significance between the decision quality and the preferred visual display mode ($p= .234$, level of significance 0.05).

Table 7 shows the participants took a longer time to make decisions when using dynamic visual displays than using static and text visual displays. ANOVA was used to analyse but the difference between different preferred visual display modes and decision making time was not significantly different ($p= .113$, level of significance 0.05). Therefore, the second research question that there is no difference in terms of the quality of decision making and decision making time when participants use a particular type of visual displays is not rejected.

Table 6 - Visual Display versus Decision Quality (Profit/time)

Visual Displays	*No of Participants*	*Mean Profit/Time*	*Standard Deviation*
Dynamic	143 (86.2%)	$17.5	3.4
Static	16 (9.6%)	$16.2	4.9
Text	7 (4.2%)	$16.8	4.0

Table 7 - Visual Display versus Decision Time

Visual Displays	*No of Participants*	*Mean Time(mins)*	*Standard Deviation*
Dynamic	143 (86.2%)	49.7	18.2
Static	16 (9.6%)	44.8	16.9
Text	7 (4.2%)	40.6	19.4

Table 8 shows that the mean profit/time increased when more than one display mode was used. ANOVA was used to analyse if there was any statistically significant difference between the quality of decision making and decision making time when participants used one or more visual display modes. The number of display mode changed and the decision making quality was not significantly different (p= .056, level of significance 0.05). Therefore, the research question that there is no difference in terms of the quality of decision making when participants use more than a particular type of visual displays is not rejected.

Table 9 shows the mean time participants spent on making decisions was similar regardless of the number of display modes attempted. Nevertheless, the participants took much longer time to make decisions when they changed display modes three times. The number of display modes tried and the decision making time was significantly different (p= .03, level of significance 0.05). Thus, the research question that there is no difference in terms of the decision making time when participants use more than a particular type of visual displays is rejected.

Table 8 - Change of Visual Display Mode versus Decision Quality (Profit/time)

No. of Changes	*No. of Participants*	*Mean Profit/Time*	*Standard Deviation*
No change	94 (56.6%)	$16.8	3.9
One	27 (16.3%)	$18.4	3.2
Two	23 (13.9%)	$17.6	2.9
Three	19 (11.5%)	$17.9	3.5

Table 9 - Change of Visual Display Mode versus Decision Time

No. of Changes	*No. of Participants*	*Mean Time(mins)*	*Standard Deviation*
No change	94 (56.6%)	46.9	17.2
One	27 (16.3%)	47.7	18.8
Two	23 (13.9%)	46.4	17.6
Three	19 (11.5%)	63.9	17.3

5. CONCLUSION AND FUTURE RESEARCH

From this experimental study, it was found about half of the participants were not too sure which visual display mode could aid decision making so they tried out other display modes but the other half of them were happy to use the first chosen visual display mode throughout the experiment. This suggested any decision support systems software should be context sensitive, i.e. giving the users the liberty of using different modes of visual display to cater for the different needs of the users. It would be to have more experiments of a similar nature to find out if there is any "optimal" number of display modes which an user can choose from so as to build an effective DSS visual display framework. Another area for further research is to compare the users' satisfaction of having and not having the choice of different visual display modes.

Contrary to some beliefs, it was found that the favourite visual displays at all times were dynamic. This clearly suggested that "a picture" is worth more than words. The second most "preferred" display mode was static, followed by text. The percentage of participants who used the dynamic visual display mode at the beginning was almost identical to the final chosen display mode. However, slightly more participants used text mode initially than static mode but the preferences reversed afterwards. More analysis could be done to see if the participants after trying different display modes choose to return to their first visual display mode . Furthermore, it would also be interesting to find out if there is any national cultural difference between the preference of visual display modes and the effects of it.

Since the number of participants who chose dynamic visual displays was so out-of-proportion with the other two modes, it was not very clear whether dynamic visual displays aided decision quality and accelerated decision time or not. More participants could be asked to participate in the experiments. Alternatively, a longitudinal research could be conducted to find out if their behaviour would change when they are more experienced.

The number of display modes tried had little effect on the decision quality but obviously made the decision makers more inefficient if they changed display mode more than three times. Since there were only three visual display modes, participants should be able to find the most comfortable one after trying all three out. Those who tried the same display mode more than once could indicate that they did not find any visual display mode which could help decision making. Again, more experiments could be conducted to see if users behave similarly when given more or less than three display modes. It is very likely that there is a correlation between the number of visual display modes and the decision time. From this research we can tentatively draw the conclusion that the type of visual display mode does not affect the quality and the time of decision making significantly, but when the number of changes of display mode exceeds the given number of choices, the decision making time is slowed down significantly.

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DECISION SUPPORT SYSTEMS IN THE INTEGRATED PRODUCTION MANAGEMENT CONTEXT

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Abstract

Many Slovene manufacturers face increasing competition which demands continuous improvements in products and productivity. The well-known methodology of Computer Integrated Manufacturing (CIM) allows manufacturing companies to remain competitive. Effective CIM systems require integrated information systems along with Decision Support Systems (DSSs) to improve business decision making. This paper proposes Business Intelligence Software (BIS) tools of the SAS System as the framework for the development of decision support systems (DSSs), which incorporate operations research modeling techniques, for an integrated production management. The application of DSSs including friendly Graphical User Interface (GUI) for the solving of linear programming problems decomposed from CIM architecture is shown as well.

Keywords

Information systems, operations management, decision making, computer-integrated manufacturing, linear programming.

1. INTRODUCTION

The transformation of the former Slovene economy, known as self-management or agreement economy, to a free-market economy creates new demands for the Slovene manufacturing companies. Many firms are just beginning to be faced with the problem of the increased competition. Manufacturing organizations operate in a difficult environment which is desperately short of capital and increasingly competitive. Therefore, acceptance of changes in manufacturing methods and manufacturing philosophy is a vital prerequisite for continued progress. An increasing number of the Slovene managers are quite aware that they need a strategic program along with the requisite knowledge to effectively use new information technology. They realize that this change is necessary to improve manufacturing efficiency which will then make it possible to respond in time to market demands.

Computer Integrated Manufacturing (CIM) technology helps to meet strategic business objectives, such as: fast response to market demands; better product quality; reduced production costs; enhanced performance; shorter lead times; reduced inventories; minimum work-in-progress and market flexibility. Effective CIM requires computer software to control automated processes, regulate production facilities, and generate information to support operational, tactical, and strategic decision making.

In order to contribute to solutions being able to cover the above needs, some initial results were obtained in working on a new research project called "Methodology for specifying computer-aided production control". The aim of the project is to develop an advanced methodology for performing the analysis of requirements and definition of specifications for comprehensive computer-integrated production control systems. The methodology of the project proposes the solving of several types of problems, such as Computer Aided Decisions Support on different levels of the organizational structure, Production Planning and Control, etc.

In line with the objectives of the mentioned project, the paper shows on the main decision-making problems derived from a CIM architecture (from a strategic decisions to production constraints). Each one should find solution thanks to many models and methods of Operational Research which can be adapted for industrial applications. A skillful solution of this situation represents the SAS System for the information delivery with BIS that can be applied for developing various types of the user-friendly DSSs which incorporate the traditional operations research modeling technique.

In addition, the paper presents the usefulness of DSS utilizing linear models for solving some of operations management problems (middle management) in the context of the multilevel organizational structure. Finally, a simple theoretical example of an operations management problem (product-mix problem) is represented, and its solution is discussed to illustrate the purpose of such DSS, which employs the capabilities of BIS, from the aspect of better decision making.

2. INTEGRATED PRODUCTION MANAGEMENT ASPECT OF DSSs.

The decision-making requirement is an important component of organizational links. Decisions being a predominant result of managers' task define the management as a decision-making process. The efficiency of decision making is conditioned by the quality of information that constitutes the basis for the numerical and logical part of the decision-making process. Much of manager's time is spent in gathering and evaluating information so that he or she will know if decision is needed, and the necessary background information will be available if it is. Making and implementing decisions are a crucial part of management. The success of business and non profit organizations hinges on their ability of to make good decisions and to implement their decisions well. Managers must reach decisions on objectives and plans for their organizational units. They must decide how to: (1) direct, (2) organize and (3) control. They must not only make many decisions, but also guide subordinates in reaching decisions of their own.

In a production enterprise several types of decisions are possible such as decision making on the production function, or decision making on the entire enterprise. Decisions on the production function such as planning and control are known as the operational decision making, decisions on business are defined as the business decision making. Thus, we can talk about operations (middle) management and general (top) management. We consider the operations function (also called the production function) an integrated system that obtains the necessary inputs, transforms them to be desirable to the customer (adds value to them), so as the customer wishes to purchase them, and gets the product (goods or services) to the customer. Figure 1 is a scheme that summarizes this view.

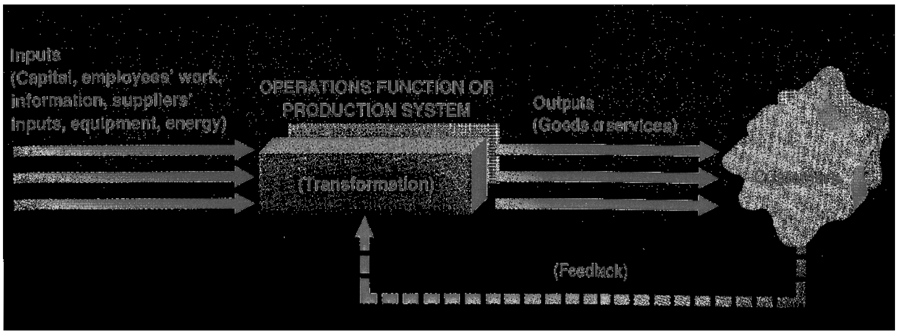

Figure 1 Conceptual diagram of a production system

The CIM architecture can be partially decomposed along two main axes: the production management aspect (vertical integration) and the logistics aspects (horizontal integration). This approach ensures that the complete production process can be defined as a production planning hierarchy, including integrated production management which can be specified with several modules, such as: order management, forecasting, product design, planning and scheduling, shop floor control with quality control and maintenance management, supplying management, inventory management, distribution management and invoicing module that are illustrated in Fig. 2.

These modular notions, which appear in every production system, independently of the size or of the factory functionality, involve a set of operational decision-making problems at various levels throughout the organization, which require the implementation of DSSs utilizing OR models and methods (management science tools) to improve the effectiveness of business decision making.

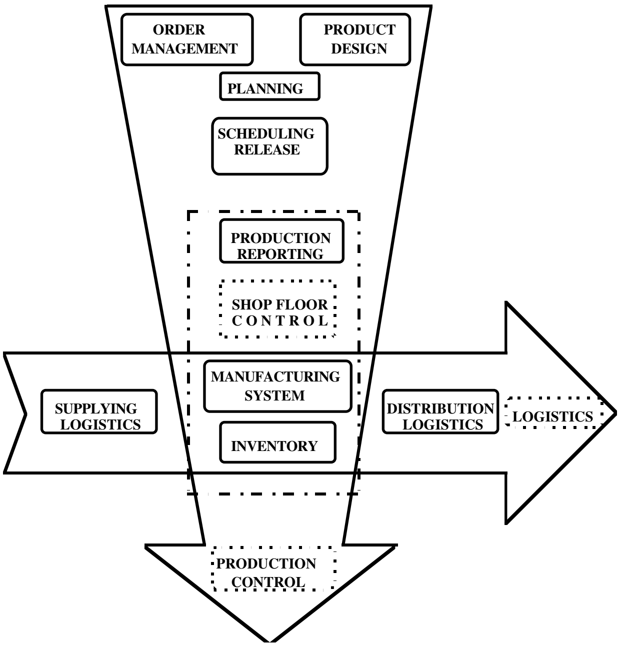

Figure 2 The model of Integrated Production Management

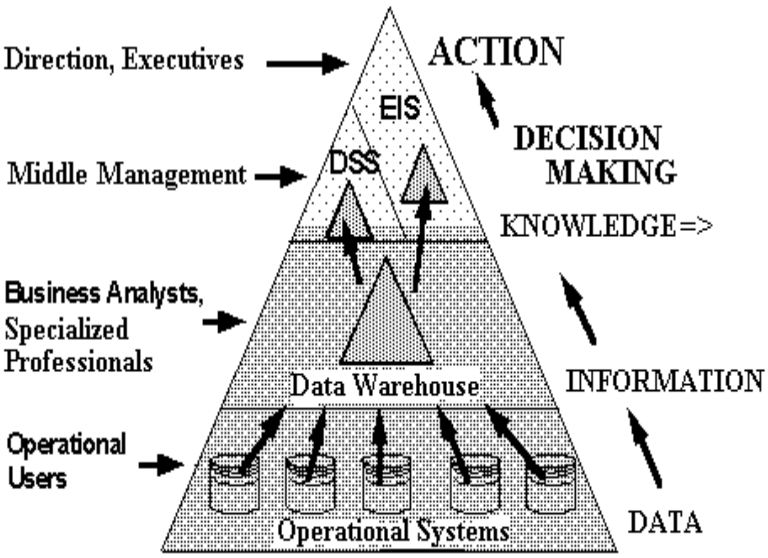

Figure 3 The structure of the SAS software for the information delivery

An effective solution in this case provides the use of the SAS System for the information delivery (see Fig.3). It includes Business Intelligent Software (BIS) which comprises a sophisticated suite of tools and technologies to support all dimensions of organizational decision making. This is accomplished in the most modern organizations by providing a powerful access to all kinds of data (data warehousing), easy-to-use data exploitation tools, and capabilities for presenting useful information. Only the SAS System provides a complete end-to-end data warehousing solution. In this case the decision support data are derived from the operational data, but are continually refreshed and readily accessible to managers.

Diverse business goals such as improving productivity, reducing costs, increasing return of investment, maintaining quality, maximizing profitability can be achieved by the SAS data warehouse exploitation including a large range of powerful tools (BIS) such as the operations of research, query, graphics, data visualization, EIS (executive information system), OLAP (online analytical processing), forecasting, and so on. Operations research (management science) tools handle everything from the decision analysis, and project management to mathematical programming. These comprehensive tools can be used for strategic planning, production and operations management, project management, distribution planning and more.

3. IMPLEMENTATION ISSUES OF DSSs UTILIZING MATHEMATICAL MODELS

lar notions of CIM architecture show a wide variety of mathematical programming problems which can be solved by linear, integer, mixed-integer, nonlinear, quadratic, and network flow programming. Some of these problems that can be modeled as linear or mixed-integer programs are listed bellow. In practice, models often contain several types of problems.

- Product-mix problems which find the mix that generates the largest return when there are several products that compete for limited resources.
- Blending problems which find the mix of ingredients to be used in a product so that it meets minimum standards and minimum costs.
- Network flow problems which find the optimal flow of material through a network -- networks have to provide supply and demand at nodes, cost and capacities on arcs, and multiple products flowing through the arcs.
- Transportation problems which find the optimal assignment of source nodes to demand nodes.
- Time-staged problems are models whose structure repeats as a function of time. Production and inventory models are classic examples of these problems. In each period, production plus inventory carried minus current demand equals inventory carried to the next period.
- Scheduling problems which assign people to times and places so as to optimize peoples' preferences while satisfying the demands of the schedule.
- Capital budgeting and project selection problems which ask for the project or set of projects that will yield the greatest return.
- Cutting stock problems which find the partition of row material that minimizes waste and satisfies demand.

In this paper, the main point is in tailoring the DSSs to these class of the above mentioned application areas (specific situations). In this case the BIS capabilities were used as the framework for the development of a flexible computer-based DSS which incorporates linear modeling technique. To support an easy to use and effective exploitation of the linear programming capabilities, the graphical user interface (GUI) was designed and developed at the Kranj faculty last year. With this GUI - this Windows application is based on object-oriented programming - managers navigate through a linear programming application by pointing and clicking with a mouse on appropriate selections. GUI menu choices are icons that users can select instead of typing numbers and letters (see Fig. 4).

Thus, this prototype of DSS provides data management and modeling capabilities to assist users in making effective operational management decisions, such as: planning for operations and capacity, plant sizing and location, distribution logistics, inventory management, etc. It also enables managers to access all data in a manufacturing organization, from flat files to database management systems, such as DB2, ORACLE, SAP/R3, etc. which is an important advantage of such a DSS.

The following example of a simple product-mix problem (see Table 1) want to show the usage of DSS including a friendly graphical user interface (GUI, see Fig. 3), which provides an effective application of BIS tools, such as mathematical programming software. This example also illustrates how DSS can be adapted to different environment and circumstances - in this case linear and integer programming in the CIM environment.

Table 1 Input data and the structure of a simple product-mixed problem

Product-mix problem: maximize the profit Z = 5X + 4Y	Items ------------ P1 P2	Inventory constraints
the components:		
A	$1X+3Y$	≤ 21
B	$2X+3Y$	≤ 24
C	$2X+1Y$	≤ 16
Price Coefficients	5 4	
Decision (structural) variables	X Y	

Table 1 shows that a firm produces two items, P1 and P2, that are assembled by three components: A, B, and C. The first item (P1) consists of 1 unit of the component A, 2 units of the component B and 2 units of the component C. The second item is composed of 3 units of the component A, 3 units of the component B and 1 unit of the component C. The objective is to determine the product mix (decision variables X and Y) that maximizes the profit of the firm (Z) while not exceeding available inventory of the components in the warehouse. Each of both items P1 and P2 contributes C1=$5 and C2=$4 to profit.

Figure 3 represents the input/output screen of GUI which shows the input data of the problem and it's solution in the form of numerical results (output data) that represents optimal values of the production i.e. the number of items P1 and P2 that maximize the profit. The results are later generated of the »Primal« icon selection and show that the maximum profit (return) Z of a manufacturing company will be $46 if an operations manager decides to produce 6 articles of the item P1(X=6) and 4 articles of the item P2 (Y=4), which represent the optimal solution (production program) in this circumstances.

Moreover, if the manager needs to evaluate how sensitive is a solution to change assumptions (what if or sensitivity analysis), he can simply select the »RangePrice« or »RangeRhs« icons (see Fig. 4). This option enables managers to examine the size of a perturbation to the price (objective) coefficients or right-hand-side constants (limited resources, production time, minimum standards, etc.). For example, in the supposed product-mix problem each objective function coefficient (C1) and (C2) can vary (separately) in the range from 2.66$ (C1-2.3$) to 8$ (C1+3$) or from 2.5$ (C2-1.5$) to 7.5$ (C2+3.5$), without changes of the optimal production program (decision variables remain unchanged). Therefore, four additional maximum values of the profit (Z) can be calculated (see Table 2).

Table 2 The results of the range price analysis

C1($)	C2($)	Z($)
2,66	4	32
8	4	56
5	2,5	40
5	7,5	60

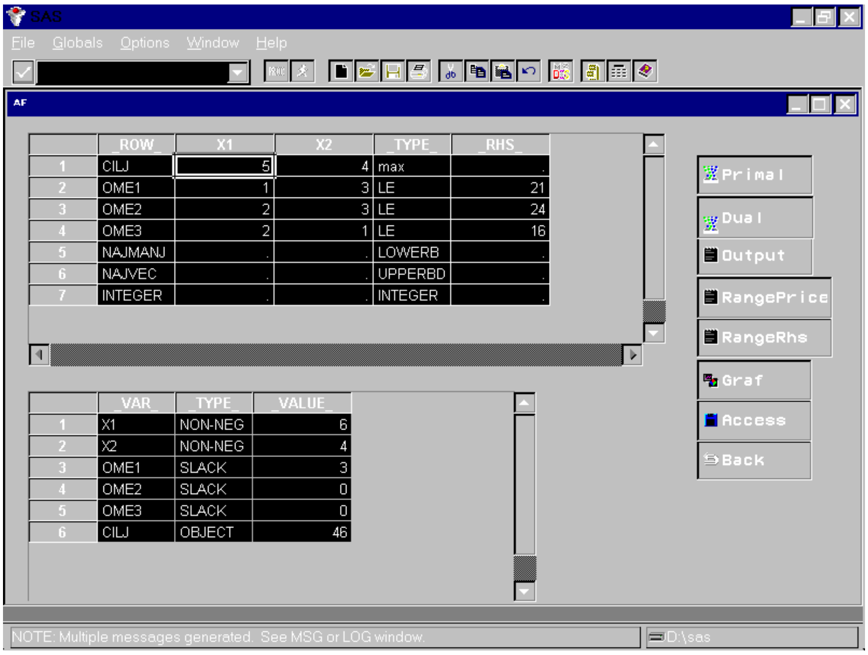

Figure 4 The screen of GUI with the input data and the results.

The results of Right Hand Side (RHS) analysis provide another information to a manager. He or she can reduce the inventory of the component A in a warehouse for 3 units (reduction of the inventory cost) without changing the optimal production program and reducing the optimal profit. Thus, we can say that the post-optimal analysis enhances the efficiency of production and inventory management which has an important impact on the manufacturing efficiency improvement according the CIM objectives .

Linear models that are assumed to be continuous, however, may be used to approximate a wide variety of problems. When the problem is not appropriate for general linear programming technique (nonlinear problems), perhaps another DSS utilizing sophisticated set of BIS tools, such as nonlinear (quadratic) programming methods, can be applied along with an adequate friendly GUI.

4. CONCLUSION

Diverse business goals such as improving productivity, reducing costs, increasing return of investment, maintaining quality, maximizing profitability can be completed by adaptation of DSSs which incorporate a more sophisticated set of software. A hypothetical example shows that BIS tools of the SAS System provide a comprehensive framework for developing of several types of the specific DSSs (context-sensitive) that are needed to generate information relevant for the managerial decision making at various levels of the organization.

From practical perspective, DSSs integration in the CIM context provides (operation) managers at every level within a manufacturing organization with the capability to increase the productivity. Ready access to analytical methods (mathematical methods) and a variety of databases encourage modeling and quantitative analysis which, in turn, lead to better understanding of problems and decision making. Moreover, the work life quality can be improved through timely interactions with a comprehensive CIM. Having the capability to enrich computer-generated reports with the analysis form a pattern enhancing displays can help the manager to integrate information from a variety of sources.

An effective application of DSS for solving linear programming problems derived from a CIM architecture is achieved by the user-friendly GUI. Rather than requiring users (i.e. managers) to remember a series of commands and options, this interface prompts apply for the next choice or action. As a result, managers are productive sooner because they can master the application by little training and documentation. The what-if analysis capability provides a comfortable learning experience for managers. The resistance to the use of quantitative models for the decision making by managers can be reduced by the decision support environment which provides an easy access to models and model management and presents the opportunity to experiment with models (modelling and simulation).

In the Republic of Slovenia, as well as in other countries, a need for building up new information systems increases each year to help organizations to achieve business objectives (CIM strategy) through the improved production efficiency. One solution for this situation is the SAS System which is one of the best representatives of the Enterprise-wide Information Delivery Systems (IDS). Some other competitive representatives of such standard packages (systems) are: SAP R/3, BAAN4, SSA, JBA, ICL MAX, IBM Mapics etc. Thus, the need to investigate the advantages, preconditions and limitations of such standard application packages for use in the Slovene manufacturing organizations has become important.

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SPATIAL DECISION SUPPORT SYSTEMS : EXTENDING THE TECHNOLOGY TO A BROADER USER COMMUNITY

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Abstract

Decision support systems (DSS) make use of a variety of information technologies and new technologies are playing an increasingly important role in decision support. One such field where new techniques have been developed is Geographic Information Systems (GIS). Spatial Decision Support Systems (SDSS) may be built using GIS techniques. Such systems are relevant to many important areas of previous DSS application, such as routing and marketing, which make use of spatial information. The widespread application of SDSS technology means that it can be used in many different situations, by many different categories of users. For this diverse group of users, some of the features of the SDSS are directly relevant, while others provide contextual information for the decision being made. This paper reviews the role of SDSS and the implications of its use in such a broad range of different contexts.

Keywords : Decision Support Systems, Geographic Information Systems**.**

1. INTRODUCTION

Decision Support Systems (DSS) are recognised as being an important category of the information systems (IS) research, for example surveys of IS research have shown DSS to be an important theme (Teng and Galletta 1990). In almost three decades since the publication of early work in the field (Gorry and Scott-Morton 1971), the DSS field has built up a considerable body of academic research and practical applications. While there is some disagreement as whether this work has provided a cumulative research tradition (Eom, Lee et al. 1993) there is nevertheless a recognisable DSS field. This is reflected in publications and conferences associated with DSS. While there are many definitions of a DSS, there is general agreement that these systems focus on specific decisions and on supporting rather than replacing the user's decision-making processes. Definitions of DSS also emphasise the need to support semi-structured and unstructured decisions. There is a consensus in the generally accepted definitions of DSS that identifies interface, database and model components, as being required to support decisions. These components must be integrated into a comprehensive system; a collection of discrete software tools may assist in decision making, but do not constitute a DSS. As technology changes, the potential for decision support increases and the effective employment of new technologies allows the DSS field advance.

The traditional DSS field largely evolved from business data processing and general purpose management information systems (MIS), which were used to process relatively straightforward numeric and text data. Such systems produce many different types of standard report by processing data using relatively simple models, which were pre-programmed into the system and not easily controlled by the user. DSS was seen as providing a system more focused on one specific problem area where the user had greater control over the operation of the system. The DSS user was expected to have sufficient expertise, in their own domain, to interact effectively with the DSS. Historically the greatest complexity in such systems usually lay in the problem specific models; the typical skilled user would be expected to be familiar with these. Many of the systems described as being DSS were in fact management science models with relatively simplistic database and interface components. Systems developed in the past, given the limitations of the available technology, were economical in the degree of the decision support provided. Many of the indirect influences on decision making were not supported by the computerised system. Such systems concentrated on the direct information needs of the decision maker, but lacked the capacity to represent fully the broader information needed to represent fully the context in which decisions were made. The restricted range of decision criteria modelled by such systems posed problems for their acceptance, as users were unwilling to accommodate the gaps in the decision support provided by the DSS.

Alter (1980) proposed an influential taxonomy for DSS which describes a number of systems which differ in the relative importance of the database and solver components. This approach recognises that different uses have different decision needs, with consequent differences in the requirements of a system designed to support their decision making. The modelling component of DSS, the solver, directly exploits the powerful computational ability of the computer. This computational ability may be utilised for the calculation of values that directly affect the decision. In many examples of model driven DSS, this computational ability greatly extends the capabilities of the decision maker. However, the quantitative data generated by the solver may also be indirectly used to facilitate decision making. This information may be used to provide the decision maker with information that can then be integrated with other non quantitative information to help the system user reach a better quality decision. The database component of the DSS provides data for use by the modelling components of the system. In a fully integrated DSS, the solver routines will be closely linked to the database, allowing their operation without unnecessary user intervention. The database component plays an important role in allowing the user a direct opportunity to explore the data relevant to the problem. For those systems falling into the data driven DSS category identified by Alter (1980), this is the most important contribution of the system to decision making. The interface component has a role to play in allowing control of the database and the modelling components of the system. However, it also provides a representation of the problem, allowing the user easily assimilate the information contained in the database and more easily to understand the output of the quantitative procedures.

In order to provide comprehensive decision support, a DSS must fully integrate these components and allow the user easily direct their use towards a specific decision making situation. For a given decision there will be essential data of direct interest to the decision maker and transformations of this data that are directly relevant to the decision making process. However, other elements in the DSS will provide indirect support, providing data that is indirectly used to calculate variables of interest. The absence of such tangentially relevant information may not prevent an adequate decision being made, but its presence will improve the quality of the decision. In a sophisticated DSS, there exists database information, modelling transformations and interface representations that make a partial contribution to the decision making process. It is desirable that these be included in a DSS, although a useful system could exist without them. For instance, in a production planning DSS the variables of direct interest to the decision maker might be the quantities produced and the costs of production. A variety of interim calculations would be needed to derive these final values. A production planner might not be very interested in the detail of these interim calculations, but a management accountant might value detailed access to this information. Information about the pattern of production, provided by the DSS, would be of interest to the production planner and might be used to improve the quality of the decision. In a problem solving situation, specific variables are manipulated within a more general context, a comprehensive DSS should allow this environmental context inform all of the components of the DSS. Data on the context should be contained in the database, it should be processed where appropriate by the models and it should be represented in the user interface to the extent required by the user. Different users of a given class of DSS will favour different problem representations and will perceive differently the degree to which information is directly or indirectly relevant.

2. USING GIS FOR DECISION SUPPORT

Developments in other fields are relevant to the growth of DSS. One such influence is the considerable growth in the importance of geographic information systems (GIS). GIS has its origins in the fragmented use of computer technology in the 1960s for automated cartography and address matching software. The original GIS applications were of interest to geographers and those in related disciplines. While this represents quite a different constituency to that of the typical users of information systems in that period, both groups had a need to process large amounts of comparatively routine data. However, geographic data is much more complex than the routine accounting data typically found in early information systems applications. Therefore, the development of comprehensive GIS software required improvements in graphics and database techniques. By the 1980s a number of different forms of commercial GIS software became available generally based on the use of UNIX workstations. At the end of the 1980s, PC based GIS software become available; reflecting the increase in PC performance to levels previously associated with workstations.

Many areas of DSS application are concerned with geographic data, including one influential early example of a DSS, the GADS system(Grace 1977). The display of maps has been a feature of DSS and researchers have noted that computer technology can greatly facilitate the use of mapping data (Ives 1982). However, the technical limitations imposed on early systems meant a restricted use of spatial information which falls far short of the potential of modern GIS. There has been limited impact by mainstream GIS techniques on DSS research. GIS techniques are beginning to have an impact on DSS applications. Surveys of DSS applications (Eom, Lee et al. 1993; Eom, Lee et al. 1998) identified marketing and routing as important areas of DSS application. These fields are also recognised as areas of GIS application (Maguire 1991). In the area of routing Bodin, identified in the survey by Eom, Lee and Kim (1993) as an important author in routing DSS, has argued for incorporation of GIS in routing (Bodin and Levy 1994). Keenan (1998a) has argued for the use of SDSS for routing problems. Demographic data is widely available in a suitable format for use in GIS software. This has lead to the development of a number of specialised GIS products, for example the marketing GIS products from Tactician Corp., or the TransCad GIS that is aimed at routing and transportation applications.

Within the GIS field there is increasing interest in the use of GIS software to provide decision support. This is reflected in the increasing appearance of papers referring to spatial decision support systems (SDSS) at GIS conferences. While an increasing number of GIS based applications are described as being DSS, these descriptions suffer from a lack of agreement on what exactly a DSS actually constitutes. As Maguire (1991) points out, some authors have argued that a GIS is a DSS. In some cases, GIS applications are described as being DSS without reference to the DSS literature. Many GIS based systems are described as being DSS on the basis that the GIS assisted in the collection or organisation of data used by the decision-maker. This may be a reflection of the trend identified by Keen (1986) for the use of any computer system, by people who make decisions, to be defined as a DSS. However, other authors justify GIS being regarded as DSS in terms of the definition of DSS. Mennecke (1997) sees SDSS as being an easy to use subset of GIS, which incorporates facilities for manipulating and analysing spatial data. These differences of definition reflect the differing needs of decision-makers that use spatial information. For many of the current SDSS applications, the main information requirement of the decision-makers is for relatively structured spatial information. This group may indeed find that standard GIS software provides for their decision-making needs.

The DSS literature incorporates many definitions of DSS (Mallach 1994 pages 5-7). Many widely accepted definitions of DSS identify the need for a combination of database, interface and model components directed at a specific problem. In terms of these definitions a GIS would not be regarded as a DSS as it lacks support for the use of problem specific models. However, the view of GIS as a DSS is not entirely without support in the existing definitions of DSS. Alter (1980) proposed an influential framework for DSS which includes data driven DSS that do not have a substantial model component. Standard GIS software could be regarded as an analysis information system in Alter's framework, the critical component of such a system being the database component. Common to all definitions of DSS is a sense that these systems must support a particular type of decision. This characteristic distinguishes DSS from general purpose management information systems (MIS). While GIS applications may contain the information relevant to a decision, they are usually general purpose systems, not focused on a particular decision. For some decisions, where the standard features of a GIS provide the information essential to the decision maker, a GIS may indeed be a DSS. However, for the wider user community of potential SDSS users, a GIS can be regarded as the starting point for building a DSS.

3. BUILDING SDSS FROM

SDSS can therefore be seen as an important subset of DSS, incorporating GIS techniques with other modelling approaches, whose potential for rapid growth has been facilitated by technical developments. The availability of appropriate inexpensive technology for manipulating spatial data enables the creation of SDSS applications. The benefits of using GIS based systems for decision making are increasingly recognised. In a review of GIS, Muller (1993) identified SDSS as a growth area in the application of GIS technology. However, the value of SDSS is not determined by its innovative use of technology. Instead, the contribution of these applications will be determined by how well they support the need for a spatial component in decision making.

Because of the variety of decision-making situations where spatial information is of importance, clearly SDSS will be an increasingly important subset of DSS in the future. It is useful to examine the relationship of GIS software to such systems. Densham (1991) discusses the development of DSS in the context of the framework proposed by Sprague (1980)(Figure 1). In Sprague's framework, a DSS may be built from tools, individual software components that can be combined to form a DSS. These would include programming languages, programming libraries and small specialised applications. At a higher level in Sprague's framework are DSS generators, from which a specific DSS can be quickly built. Generators may be built from lower level tools. Sprague envisioned that different specific DSS applications would require different combinations of the generator and tools. Sprague used GADS (Grace 1977), which can be regarded as a form of GIS, as an example of a DSS generator.

In building DSS, specific generators have been designed for certain classes of problem. In other situations general-purpose software such as spreadsheets or DBMS packages have been regarded as generators. In modern DBMS and spreadsheet software, the use of macro and programming languages facilitates the creation of specific applications. Various generators have strengths and weaknesses in terms of their provision of the essential components of a DSS: an interface, a database, and models. In the case of a spreadsheet, modelling is the basic function of the software; various interface features such as graphs are provided, but the database organisation is simplistic. DBMS software, such as Access or Paradox, has good database support, provision for interface design using forms, report and charts, but almost no modelling support. In this case, the modelling support has to be added to the specific DSS built from such a system.

In Sprague's framework, the SDSS builder may make use of tools, which provide some, lower level data processing. In software design these might include operations such as sorting or searching which are important algorithms in their own right but which are not of direct interest to the decision maker. The decision regarding the appropriate mix of DSS tools and the use of a generator is an important component of the process of building a DSS. However, the design of a DSS is likely to be strongly influenced by the availability of DSS generators for that class of problem. The DSS solutions actually constructed are strongly influenced by the perceived availability of suitable generators. Consequently, the effective application of DSS technology can benefit from additional generator software becoming available. Awareness of the potential of the use of GIS based systems as DSS generators will lead to problems, currently being solved in other ways, being approached by using a SDSS.

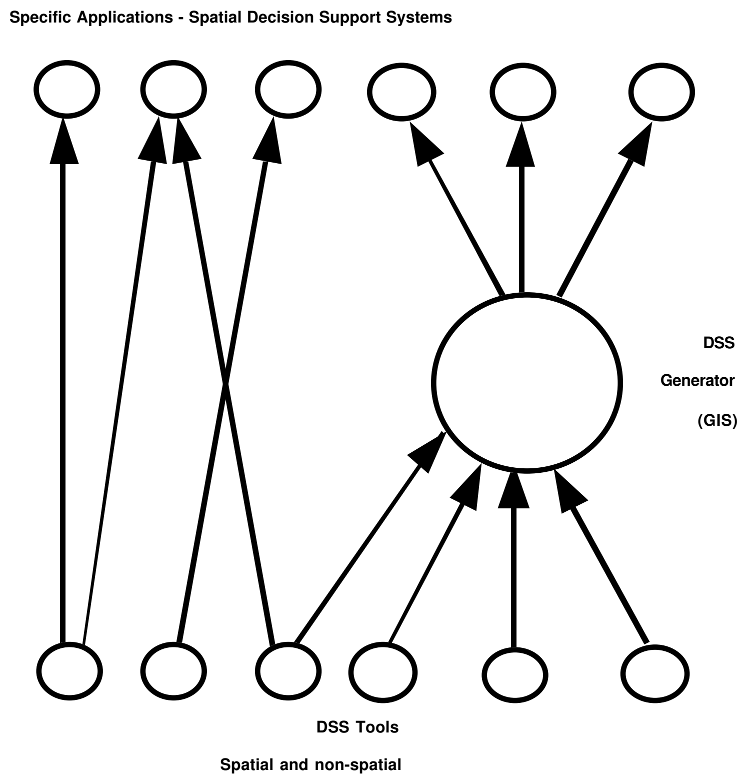

Figure 1 : Technology Levels of SDSS (adapted from Sprague, 1980)

GIS can be distinguished from other forms of information system by the distinctive data stored and processed by such systems. Geographic data comprises three fundamental spatial structures, points, arcs and polygons. Each of these can have conventional non spatial or attribute data associated with it. The characteristic nature of SDSS is determined by components that store and allow manipulation of these forms of spatial data. Many problems of interest to decision makers use spatial data. For SDSS techniques to be of interest, real world problems need only have a spatial component in one aspect of the decision making. While important elements of the decision process may use only non-spatial (attribute) data in the SDSS, the spatial operations may have an important role to play. For example, the data set to be used for the non spatially based modelling process may be identified by spatial operations. For example, spatial analysis may determine the number of potential customers for a new retail outlet; this could provide data for use in a financial model. The decision maker is concerned with financial data; the spatial component of the system provides a model of the real world context in which the financial planning is taking place. Conversely, the outcome of a non-spatial model may identify spatial operations that need to be performed. For instance, a vehicle routing algorithm may produce truck routes; spatial techniques could then identify the areas affected by noise resulting from the increased traffic. Vehicle routing, a well-established area of DSS research, is a good example of the potential for SDSS. Routing problems routinely employ data on points and arcs and SDSS would facilitate an extension of these problems to more advanced ones which also consider polygon data (Keenan 1997). Users of systems such as routing DSS, unlike more traditional GIS users, have no direct interest in the basic spatial processing techniques. This type of user is focused on the information needs of the routing process and requires that the system facilitate the provision of this information, by automating much of the spatial processing required.

In DSS applications, the focus of the decision-maker is on the decision being made. The output from the DSS is of interest only to the extent that it facilitates decision making. The DSS user wants to make use of the DSS to explore aspects of the decision. This should not require the user to go through long sequences of commands, to enable data move between different modules of the system. It is central to the design of DSS that the modelling routines can automatically extract the relevant data from the database component of the system. In a DSS, the user should only need to intervene in the system to direct the modelling process; not to conduct the basic operations needed for modelling. In a SDSS the models must be able to make use of the spatial database tools as appropriate. This requires that the SDSS be built with modelling tools that allow the model designer access to the database and interface components of the SDSS. In order to be used as a DSS generator, GIS software must allow easy automatic interchange of data between the GIS modules and modelling techniques operating on non-spatial elements of the data. This may entail a departure from traditional assumptions in GIS design of the user operating the system by direct manipulation of interface commands. If it is to be used as a SDSS generator, then GIS software must make data available in a format that is appropriate for modelling techniques drawn from other disciplines. This lack of integration hinders comprehensive use of GIS as a SDSS generator for a variety of problems that use geographic data.

As standard GIS software may lack the problem specific models needed for SDSS applications, its role can be seen as a software component, which may be used to build a SDSS. In assessing the suitability of GIS software for building SDSS, two major issues arise. Firstly, can GIS be effectively integrated with other software to build a complete system? GIS used in conjunction with other software may aid decision-making, but not constitute a DSS. A complete system providing full decision support requires that models and data can interact within the system. User intervention is needed to alter modelling parameters that affect the decision; such intervention should not be needed to link the modelling and data components of the system. The second issue is whether systems can be built more easily using GIS as a DSS generator rather than by using alternative approaches. The use of software that simplifies system development, enables a DSS system builder spend time designing features which directly support the decision being made, rather than having to spend a lot of time attempting to understand the tools or generators being used. Current trends in software development allow the integration of distinct software components and facilitate the use of modelling components with GIS software (Keenan 1998b). These features allow data to pass between the modelling, interface and data components of the GIS. More importantly, they also allow control over the operation of these elements.

An important group of SDSS users is those in the traditional areas of application of GIS, in disciplines such as geology, forestry, and land planning. In these fields GIS was initially used as a means of speeding up the processing of spatial data, for the completion of activities that contribute directly to productivity. In this context, the automated production of maps, in these disciplines, has a role similar to that of data processing in business. In these subject areas, there will be growth of decision-making applications in much the same way as data processing applications evolved into DSS in traditional business applications. An example of this type of application is the DSS for the assessment of geological risk by Mejia-Navarro (1995). This group is distinguished by a direct interest in the spatial operations provided by the SDSS and considerable background knowledge of the spatial techniques used. For this category of users, the spatial data and the spatial processing techniques are of direct interest rather than simply providing the context in which other variables are being manipulated.

The greater complexity of spatial information processing and its greater demands on information technology have lead to the ten to fifteen year time lag identified by Densham (1991). As information technology costs decline, inexpensive personal computers can now cope with the demands imposed by the manipulation of spatial data. The rapid increase in the 1980's in the use of database managers, led by Dbase II, is being emulated by the increase in the use of spatial database tools at present. In the context of decision support we are now seeing the movement towards the widespread use of PC based GIS systems that reflects the move towards PC based DSS in the 1980's.

The second group of decision-makers, for whom SDSS can make an important contribution, is in fields such as routing or location analysis. Although the spatial component of such decisions is clear, in the past DSS design has been driven predominantly by the management science models used. There model driven systems often had very limited database or interface components and the DSS provided little contextual information to the user. In the future these models will be incorporated into GIS based SDSS, providing superior interface and database components to work with the models (Keenan 1998b). The role of the superior GIS data handling facilities will be to provide a richer context for the use of the specific models and for display on the user interface. For this class of problems the variables of direct interest might be distance travelled, the number of vehicles used and the loads on each vehicle. Early routing DSS would only have stored data related to these directly relevant variables. However, the use of GIS technology allows the inclusion of other indirectly important information. For example the inclusion of elevation data would allow more realistic travel times be used in quantitative modelling of routes. The display of distinctive natural features such as rivers or mountains on the interface can make it much easier for the user to understand the representation of the routes generated. This synthesis of management science and GIS techniques will provide more effective decision-making. Keenan (1997) has argued that the use of GIS techniques can extend the range of decision support for vehicle routing problems, allowing consideration of path constraints that have not been comprehensively modelled in the past. This group of potential SDSS users has limited experience of using manual spatial techniques. Such users are not usually directly interested in the spatial processing techniques provided by the SDSS but only in the interaction of these techniques with the management science models. However, the secondary use of spatial data by the models and the display of spatial information on the interface can greatly enrich the decision making process. This group can benefit from the geographic context being fully reflected in the problem representations used.

The third group of decision-makers who will find SDSS important include those where the importance of both spatial data and modelling is somewhat neglected at present. In disciplines such as marketing, additional possibilities for analysis are provided by the availability of increasing amounts of spatially correlated information, for example demographic data (Mennecke 1997). Furthermore, the geographic convenience of product supply relative to customers' locations is an important tool of market driven competition. The availability of user friendly SDSS to manipulate this type of data will lead to additional decision possibilities being examined which are difficult to evaluate without the use of such technology (Grimshaw 1994). The group of potential SDSS users have little background in spatial processing and are not usually experienced users of DSS technology of any type. This category of users are not accustomed to the restrictions on model realism and the interface limitations that many users of management science based DSS have been willing to put up with in the past. Such users will therefore require systems that are straightforward to use and which do not require the user to accommodate artificial restrictions on the problem representation. Such users will benefit from the more realistic modelling and interface representations facilitated by the inclusion of additional contextual information provided by SDSS and other sophisticated technologies.

4. MULTIPLE DECISION CONTEXTS FOR SDSS

The increasing suitability of GIS software for use as the basis of a SDSS reflects these trends towards integration. However, it also reflects the greater awareness of the need to extend the use of spatial techniques to a wider range of applications. SDSS represents a form of ‘second order’ DSS where complex and mature technology acts as a basis for systems to support a general class of problems. This general technology is synthesised with more specialised elements, for example models, to form a problem specific DSS. This wider set of applications inevitably involves many potential users of the SDSS who are not drawn from the traditional geoscience disciplines. The extension of SDSS use to such a broader cross section of users offers great potential benefits but also raises a number of interesting issues. How should the design of a SDSS for a business user differ from a system designed for a geologist? Can users make good use of such systems, without substantial training in the use of spatial processing techniques? While some of these issues arise only in the context of SDSS, the issues arising from the design of these more advanced systems are also of interest to DSS designers generally.

SDSS applications, on the other hand, contain relatively complex spatial database structures and powerful tools for manipulating the data stored in these structures. A common feature of all such systems is the use of spatial data, points, lines and polygons, but a wide variety of models may be applied to this basic data. GIS based DSS applications can make use of the spatial data processing provided by the GIS; these techniques would be supplemented by problem specific models for a given application. However, the wide range of areas of SDSS application implies the existence of a broad spectrum of potential users of SDSS. These users will not be interested in the full range of spatial processing techniques but only in those relevant to a given application. The trend in the future is likely to be for a growth in the use of SDSS by business users without formal training in disciplines such as geography or cartography (Mennecke 1997). This poses a challenge for SDSS builders to cater for this diverse user group using systems built on a similar basic spatial processing platform

This user diversity can largely be catered for if there is a clear focus on the specific problem, rather than on the technology used. For ease of system building a DSS generator may be used, such as a GIS, that has multiple functions. However, for any one problem or one user many of these facilities may not be need. Existing design frameworks such as the ROMC (the representations, operations, memory aids and controls) approach (Sprague and Carlson 1982) should be used to identify the system features of interest to the specific user. The general purpose features of the generator can then be customised by the system builder to provide the representations, operations, memory aids and controls appropriate to the problem. These may differ substantially from user to user. It is an important characteristic of successful information systems that they provide information in a format appropriate to the user. Different users of a given type of information may be accustomed to quite different presentation formats for the information. Distinctive nomenclature may be used in different disciplines. This poses a problem in the context of SDSS where the language used by geographers, which underlies documentation and interface design for GIS software, may be quite different than that used by potential users of SDSS. A successful system must provide system builders with the flexibility to accommodate user preferences. The DSS components can be configured to provide direct users access to information of interest, while other features of the DSS provide contextual information to enrich the decision making process. Contextual information can be found in the database, processed by spatial models and displayed in an appropriate representation on the interface (Table 1).

Table 1 : Contextual Information in SDSS

	Directly Relevant	Contextual Information
Solver	customised business models e.g. marketing, routing, location	general spatial processing tools e.g. buffering
Database	data on planning units, e.g. routes, administrative regions	elevation data, base geographic entities, points, arcs, polygons
Interface	decision outcomes, e.g. routes, areas of influence	geographic features, e.g. lakes rivers, mountains

If GIS software is seen as a DSS generator, rather than as an end in itself, different strategies for interface design might present themselves. The aim of the system builder must be to cater for the problem representation of the user, the logical view of the problem, rather than provide a system too closely related to the physical geographic data. Different users might have different system representations and operations, in similar way to the concept of subschemas providing a distinctive presentation of a database to a user. Not all the data in the system need be made directly available to every user. Even if limited access to information is provided, the full range of GIS operations need not be made available. Simplified information representations, that might be appropriate for users who only indirectly employ that information, might be inadequate for other users directly interested in that data. Unlike earlier systems modern DSS can be much more complex, for example GIS based SDSS, this implies multiple features at a level of detail that goes beyond that needed by any one user.

A user based design will not impose unfamiliar control concepts on the user. For example, a typical operation in GIS might involve selecting a procedure from several levels of submenu. The spatial data to be used for this operation might be then identified by drawing a box on the screen with the mouse. This approach presents problems for the SDSS user who is not familiar with many of the operations provided by the GIS. A more user centric approach might allow the user draw the box on screen with the mouse and then a menu would appear offering only that subset of operations appropriate to that set of data.

Artificial intelligence (AI) techniques might be used to facilitate this interface simplification. Two existing interesting examples of DSS prototype which use AI techniques, Tolomeo (Angehrn and Lüthi 1990) and Alto (Potvin, Lapalme et al. 1994) can be regarded as a form of simplified GIS. Tolomeo allows the users describe the problem visually and the interface includes a map that includes the representation of visual features other than those that can be directly manipulated by the user. These features provide the geographic context within which the user specifies the problem in terms of the cities to be visited, etc. This type of intelligent DSS interface could usefully be incorporated in a fully fledged SDSS to increase its acceptance to a broader user community.

5. CONCLUSION

Given the advances in information technology, modern DSS can incorporate a more extensive directly and indirectly relevant information for a given class of decisions. The designers of these systems must aim to provide maximum user control over those aspects of the decision where the user has specific expertise, while providing the user with maximum support for areas where the user is less expert. This may require that DSS generator software, such as GIS, be designed with flexibility in mind so that different types of user can make use of the intelligence in the system for less critical parts of the decision.

We suggest, therefore, that much DSS development in the future will take place using relatively complex combination of DSS generators and tools. A substantial variation in the type of problem and user will exist within the general group of systems built from such generators. Spatial decision support systems are a good example of a class of sophisticated DSS. Such systems have largely been used in the past for problems where the manipulation of spatial data was the key or only information component of the decision to be taken. Such users required full control over the spatial operations in the system in order to improve the quality of the decision. In the future, the use of SDSS will be extended to applications where the spatial information is only an interim stage or a subset of the information required for the decision. Such information provides the geographic context within which specific decisions are taken. Users dealing with this broader set of applications need to be given control over the important variables in the decision while other processing is performed without the need for extensive user interaction. With the development of such systems, new classes of decision and new types of user can be effectively supported.

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CONTEXTUAL DETERMINANTS OF THE USE OF AN ORGANIZATIONAL SUPPORT SYSTEM IN

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Abstract

The literature review provides contradictory evidence regarding the social effects of collaborative technologies such as groupware and electronically mediated communications in support of organisation-wide decision-making processes. Due to their inherent characteristics, these technologies are believed to contribute to freedom of speech, equality of access, and the lowering of social barriers, and thus are considered to advance participatory, democratic decision making (a technological deterministic approach). However, many recent studies challenged these views and provided evidence to the contrary. This paper attempts to address the core problem in understanding the social effects of technologies on organisational decision making processes which is the complex interactions among the actors and these technology as contingent upon a *social and cultural context*. This paper reports research results from a case study of an **Organisational Support System** (OSS) in a consultative organisational change process in an Australian University. Through the provision of a “virtual discussion forum”, the OSS based on **e-mail** and **intranet** was deployed to enable *equal participation* of all University members, and *freedom of expression* (“everybody will have their say and will be heard”) and to contribute to more *participative and consensus based decision making*. The data collected in this research (messages, documents, interviews, notes) provide mixed evidence regarding the attainment of these objectives. We identified significantly different modes of use of the OSS across the institution, by departments, groups and individuals. We found that contextual determinants such as management traditions, the use of power, and the possible existence of a culture of consultation, conditioned the modes of use and consequently the role the OSS played in the process. On the other hand, we also observed how the OSS and the Consultative process in turn impacted upon these contextual factors.

1. INTRODUCTION

The use of information technologies (IT) to support organisation wide decision-making has become commonplace. Information sharing and problem identification, discussions about problem situations, alternative actions and expected outcomes, selection and coordination of actions, to name just a few, are performed not only in face-to-face but also in any-time-any-place interactions. Organisation wide participation in decision-making has become significantly enhanced through the deployment of a variety of collaborative technologies such as group decision support systems (GDSS), computer-supported cooperative work (CSCW), groupware, e-mail, computer-mediated-communications (CMC), computer conferencing and their different combinations. The ideals of open communication and equality access, freedom of speech and participatory, democratic decision making, seem to be consistent with the assumptions behind the design of these technologies. They are, as Sproull and Kiesler wrote, "surprisingly consistent with Western images of democracy" (1991b, p13). They found CMC and especially e-mail instrumental in fostering democracy in organisations.

One important assumption behind these technologies is the *equality of access* which means that all the participants have an equal opportunity to access the communication network and information in the system, to contribute to the discussion, and affect the opinion of others. Equality also means an equal time span for the communicative performance of participants with no regard to their status differences (Mantovani, 1994). This equality of access is particularly emphasised when contrasted to some of the limitation of access and status related barriers in face-to-face interactions. Mantovani found this aspect of CMC and other electronic communications really important for increasing democracy in organisations.

In a series of controlled experiments with groups of students using CMC Dubrovsky et al. (1991), Sproull and Kiesler (1991b), Kiesler and Sproull (1992) provide evidence that high-status members spoke less and low-status members spoke more, thus reducing the impact of status differences. This equalising effect however has not been confirmed by Adrianson and Hjelmquist's (1991) study of CMC in everyday work situations. These differences may be partially explained by the different populations involved in these research studies: students vs. real employees. The impact of the organisation wide electronic communications on the equality of access still remains a controversial issue.

Neilson (1997) for instance found that Lotus Notes "*democratises* information access rendering traditional structures meaningless. In Taylor-like organisations, Notes implementation wreaks havoc with command and control Weberian hierarchies. In information heterarchies, Notes provides a means for any-time and any-place access to information." (p41). Sproull and Kiesler (1991a, 1991b) provide evidence that electronically mediated communications affect *social inequalities* by softening the *status related barriers* and decreasing the *informational and emotional distance* between the center and peripheral employees. Rice (1990) on the other hand found quite the opposite - that computer–mediated communication systems tend to enforce rather than reduce status related differences. Child and Loveridge (1990) found that because these systems are designed to support existing power structures and hierarchies they facilitate existing relationships and interaction patterns, and maintain status barriers and power distance. "Electronic links primarily enhance existing interaction patterns rather than creating new ones" (Bikson et al., 1989, p102).

Technological determinism, which views various groupware and electronically mediated communications as inherently apt to support democracy, has been widely challenged. "It is apparent that some degree of technological determinism is implicit in searching first for the social effects of the new communication technology rather than the multiple ways in which individuals, social groups, and organisations control cognitive artefacts, so as to adapt them to the uniqueness of social contexts." (Mantovani, 1994, p47). The controversial evidence from research on the social effects of these technologies indicates the necessity for deeper understanding of social contexts and their subtle ways of determining the use of technology.

A significant body of research has contributed to the understanding of the *context* within which the information systems operate. Technology does not operate as a technical tool outside a social context, but rather as part of socio-technical "webs" that generate and use it (Kling, 1980, Kling and Scacchi, 1982, Kling and Iacono, 1989). In studying the context of information systems, Walsham (1993) focuses on "the various social structures which are present in the minds of the human participants involved with the system…Their interpretations of reality, their shared and contested sense of the world, create complex interacting contexts within which the information system, as a human artefact, is drawn on and used to create or reinforce meaning" (p4-5). This in turn may lead to a reinforcing existing power structures or creating new systems of authority and meaning.

The literature review shows that the expectations that the use of groupware and electronically mediated communications in support of organisation-wide decision-making will contribute to freedom of speech, equality of access, and the lowering of social barriers, and thus advancing participatory, democratic decision making, have some substance but still remain highly controversial. The major problem is the deep understanding of technology's intervention into a fabric of organisational processes or, in Zmud's words, of "complex interactions among the intentions of key actors, attributes of the technology involved, and dynamic organisational processes". (Zmud, 1990, p95)..

The issues of "complex interactions" are addressed by an exploratory case study of an Organisational Support System in the Sygma University (a pseudo name of an Australian University). Sygma went through an organisational change process (carried out as an Consultative Process) during 1997. The process involved the whole management structure and all the staff members of the University. The Organisational Support System based on E-mail and Intranet, was designed to be an integral part of the Consultative Process. The purpose of the Organisational Support System was to provide equal access to information to all staff, to enable a university-wide electronic forum for discussion, and to support the coordination of tasks and activities of the many individuals and groups involved in the process. The objective of our case study was to advance the understanding of complex interactions of individuals, groups and the organisation with the Organisational Support System, within specific social and organisational conditions. The qualitative nature of this research approach enabled us to uncover and examine contextual determinants of how the Organisational Support System was interpreted, appropriated and used by actors across the institution.

The purpose of this paper is to present the segment of this study which observed the interaction patterns, use and impacts of the Organisational Support System in different stages of the Consultative Process. To this end we first present a brief description of the case study in the next section. In section 3 we present a summary of research findings: characteristics of particular social and cultural contexts and patterns of social interactions mediated by Organisational Support System. The contextual determinants of the use of the Organisational Support System and its effects are interpreted within democratic vs authoritarian management traditions. In section 4 Concluding Remarks we summarised the findings and major implications of this study.

2. CASE STUDY

The purpose of this case study was to explore, document and interpret:

- the nature of the organisational, social and cultural contexts governing Sygma University within which the consultative decision making process (referred to as the Consultative Process) was undertaken
- the way the Organisational Support System (OSS) was used by individuals, groups and the institution
- the interaction of individuals, groups and the institution with the Organisational Support System within the context, during the Process.

The authors were involved in the study as participants in the Consultative Process. Each of the authors played an established role prior to the study. Data were collected partially using the *participant as observer* technique (Gold, 1958, Junker, 1960, Atkinson, and Hammersley, 1994) and partially as *participants engaging in reflective practice* after the event (Schon,1987). Being participants in different parts of the Consultative Process the authors also received messages, memos, discussions, documents and other materials created during the Consultative Process, including a summary of the survey administered in Sygma. The research team was also interested in collecting experiences of and insights about individuals' interaction with OSS. To this end semi-structured interviews were conducted with thirty staff members from a broad cross section of the University. The interviews were crucial not only in helping to recognise the different patterns in the use of OSS but also to understand the contextual underpinnings. The fieldwork occurred in the second half of 1997, and interviews were conducted in the last quarter of 1997 and the beginning of 1998. In the analysis both manual records and the computer support for qualitative data analysis, NUD*IST (Richards and Richards, 1993) were used.

2.1 SYGMA UNIVERSITY

The Sygma University is situated in a semi rural area on the outskirts of a large metropolitan centre. It was originally established in 1891 as a single purpose college and evolved over the ensuing years to become, upon the destruction of the binary higher education system in 1989, a part of a greater university network. It has an enrolment of more than 5500 students, and can thus be regarded as a small university. The staff body comprises of approximately 250 academic staff distributed over five faculties and approximately 420 general staff members including administrative staff, technical and scientific officers, field and maintenance staff, etc.

This University has undergone a number of restructures over the past ten years, which have been instituted on the basis of greatly varying management practices. Confronted with long term budget cuts, increased competition and other economic, political and social uncertainties, Sygma embarked on another strategic change process in 1997. This organisation-wide restructure was the first carried out as an explicitly designed consultative process . Everyone was invited to participate on equal terms. Union representatives were included in the official decision-making. An Organisational Support System based on e-mail and Intranet, was designed to enable organisation-wide communication, equal access, and broad participation.

2.2 SYGMA CONSULTATIVE PROCESS

The objectives of this Process as defined by the President of Sygma were:

- "Greater capacity to function as an integrated scholarly community with a shared sense of belonging to a common academy,
- Maximisation of our competitive capacity to pursue our academic mission with success, flexibility, and integrity,
- Improvement in our quality and quality assurance processes,
- Increase in our potential and capacity for income generation,
- Achievement of essential savings and efficiency gains."

The Consultative Process spanned three phases:

Phase 1 Pre-Planning Conference
At the beginning of 1997 the Sygma Executive issued five strategic papers which addressed: teaching and learning, research and consulting, funding and income generating, the structure and management of Sygma, and the organisational culture of Sygma. The papers were distributed widely by email and as hard copy to every staff member with an invitation to respond. Responses were distributed initially through an email discussion forum and subsequently were collated by a Consultative Process Coordinator and lodged on the Intranet, an internal website. At this stage the design of the OSS was finalised and subsequent discussions, papers written by the Executive and other staff contributions were presented, distributed and stored via the OSS (managed by the Coordinator). A survey called: *Critical Issues – Staff survey* was formed from the data arising in the discussions and sent to each staff member. Two forums open to all staff were held on each of the two campuses leading up to the Planning Conference.

Phase 2: Sygma Planning Conference and the development of The Blueprint 1998 – 2001 Principles
The Planning Conference, attended by approximately 10% of the total staff group, was held mid year to discuss and explore the major issues as raised during Phase 1 to do with the structure and function of Sygma and make recommendations to the President. The Report from the Conference was made available to the staff body through email, the Intranet and hard copy. After a short post Conference discussion the President wrote the document entitled *Blueprint 1998 – 2001 Principles,* which was first discussed by the Executive and then circulated to the total staff of Sygma for comment. The document was widely discussed by academic and

administrative units, discussion groups and public forums. 60 submissions were published on thee-mail and intranet by the Coordinator.

Phase 3: The Blueprint Principles – Implementation and Planning
The final version of the Blueprint was released. The changes to the earlier draft, some of which were significant, were based on the outcomes of Phase 2. An Implementation Plan was attached detailing the process of implementing the Blueprint, including the formation of an Implementation Coordination Team chaired by the President; the formation of four smaller teams to design the four new divisions as defined by the Blueprint; and the Joint Union-University Consultative Committee was created to oversee the Process. During this phase an increasing proportion of staff took part in the implementation teams and special purpose groups. Through keeping an accurate record of the latest team outcomes, and by enabling coordination of their activities the OSS played a vital role in the functioning of the complex web of teams and groups. The implementation phase which was intended to end in 1997 has continued into the first quarter of 1998.

2.3 ORGANISATIONAL SUPPORT SYSTEM

An integral part of the Consultative Process was a computerised Organisational Support System, based on **e-mail** and the **Intranet.** This system performs functions of an Organisation Decision Support System by supporting organisation-wide processes, enabling communication and coordinating decision-making across functional areas and levels. Considering a wide range of definitions of Organisation Decision Support Systems (ODSS), from Hackathorn and Keen (1981), to Watson (1990), Swanson and Zmud (1990), King and Star (1990), George (1990), to Carter, et al. (1992) and Turban (1993), Sygma's OSS can be seen as an embryonic version of ODSS. In the classification of Fedorowicz and Konsynski (1989) Sygma's OSS would belong to Type 2, *Structure Independent* ODSS, that "spans the organisation", and is "used by individuals outside functional or hierarchical boundaries". However, in its present version, it must be noted that the OSS does not conform to the traditional model of ODSS such as the one presented by Carter, et al. (1992) and Turban (1993).
The OSS was designed along with the overall Consultative Process with the objectives to:

- enable organisation-wide communication, discussion and sharing of information independent of time and space limitations
- maintain the repository of messages and documents created in the process
- enable effective and efficient coordination among different individuals and groups involved in the Consultative Process.

The OSS was based on the University wide communication network and included an e-mail system with 'Sygma-All' facility (enabling 1:n communication) controlled by a Coordinator, a repository of e-mail messages published on the Intranet, and a structured set of documents regularly updated on the Intranet.

The design of the OSS was based on the assumptions that Sygma embodied a democratic academic tradition and espoused broad based consultation in making strategic decisions, as well as open dialog in a non-threatening, friendly discussion climate. Various forms of public discussions, such as forums, consultative committees and conferences, had previously been practised whenever the circumstances or issues required an organisational response. An element previously missing, it was believed, was an appropriate electronic support system that would provide a virtual forum in which all members of the Sygma University could participate. The underlying assumption was that if such an OSS was available to everybody then Sygma University would use its full potential for democratic decision making. Almost all Sygma members had access to the University network and therefore were potential users of the OSS. The OSS communicated intensively with its users: it sent all the messages and documents created in the Consultative Process, prompted or requested a response from the users on particular issues (survey, discussion papers, etc.), alerted users about important events, deadlines, new documents etc. The OSS also provided a full set of accumulated messages and documents (including different versions) which could be searched and downloaded at any time. Due to these properties, the designers assumed, the OSS would empower both academic and general staff members of Sygma to participate in the Consultative Process and actively contribute to the innovation of their own work processes. Consequently, they believed, staff would not only be consulted but would feel ownership of the outcomes.

3 RESEARCH FINDINGS: A CONTEXT AND THE MODES OF USE OF OSS

The nature of the Consultative Process was such that we have to distinguish first between two levels of use of the OSS:

- **group level**: interaction of individuals among themselves, within a group and the group's interaction with others
- **organisational level**: institution wide, public interaction between individuals and groups.

The research findings at each level will be summarised here with an emphasis on the social and cultural context and the patterns of use of OSS, schematically presented in figures 1 through 5.

3.1 GROUP LEVEL

3.1.1 Authoritarian and Bureaucratic Group Context

Characteristics of the local context

- rigid hierarchical structure and authority of power,
- authoritarian and bureaucratic style of management: group leader (manager) directs and controls the work of members (subordinates)
- members' dependence on their leader
- subordination and obedience to the leader demanded
- controlled access to information

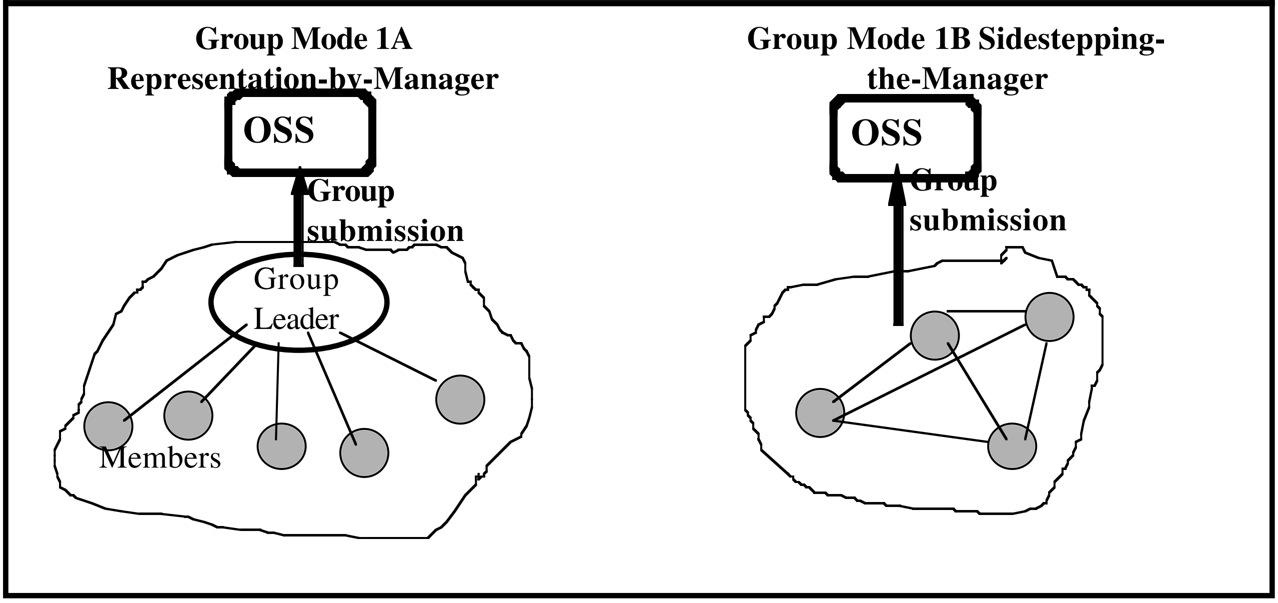

Fig 1 Authoritarian and bureaucratic local context and the modes of use of OSS

Several groups in the Sygma University exhibited an authoritarian, hierarchical and bureaucratic management model and undemocratic local culture. During the Consultative Process members of these groups were typically asked to meet with their leader or manager to discuss proposals, issues and concerns. The manager would then feel responsible to interpret and represent the group's position. He/she would for example submit the proposal or response to "higher levels", via OSS. The characteristics of the local context and the modes of use of the OSS found in this type of context are presented in Fig 1.

Due to his/her power position, a manager of this type would appropriate OSS to fit his/her management model and values (Mode 1A). Despite open access to all information in the Consultative Process and repeated invitation by the Executive to all staff to participate, members of such groups tended to feel disempowered and voiceless. Their perception of status related constraints and pressure to conform to their manager's views appeared to make them feel peripheralised in the Consultative Process. They perceived the role of OSS as assisting existing interaction patterns and social inequalities, as well as reinforcing their manager's power position, something "that is for him/her not for them".

In a few cases, however, some members of a group got together without their manager and submitted their contribution by e-mail. They perceived OSS as an <u>opportunity to avoid their manager</u> and escape the inhibiting forces within their unit (Mode 1B). Although these examples demonstrate a potentially emancipatory use of OSS, the fact that the members acted outside the "accepted" interaction patterns and did not basically change the local culture, indicates that the provision of an open communication platform, like OSS, may not have been enough to change the local culture.

3.1.2 Close Knit Group Context

Some academic groups revealed a very strong local culture (see Fig 2) characterised by a particular value system and professional standards, believed to be distinct from the rest of the University. Members of such groups felt a strong identification with their group (often coinciding with profession identification) and were committed to the betterment of their group wellbeing and the protection of their interests. Members of the smaller close knit groups openly discussed all the relevant issues (often using their group e-mail) and submitted their group position or response to the Consultative Process (Group Mode 2A, Fig 2).

Characteristics of the local context

- democratic and participative management style and consensus based decision making
- a strong sense of community, collective responsibility, and high commitment and loyalty to the group in contrast to the alienation from and mistrust towards the University
- mutual interdependence within the group; feeling of physical and emotional closeness
- the University perceived as the "bureaucracy", constraining their autonomy, academic freedom and creativity.

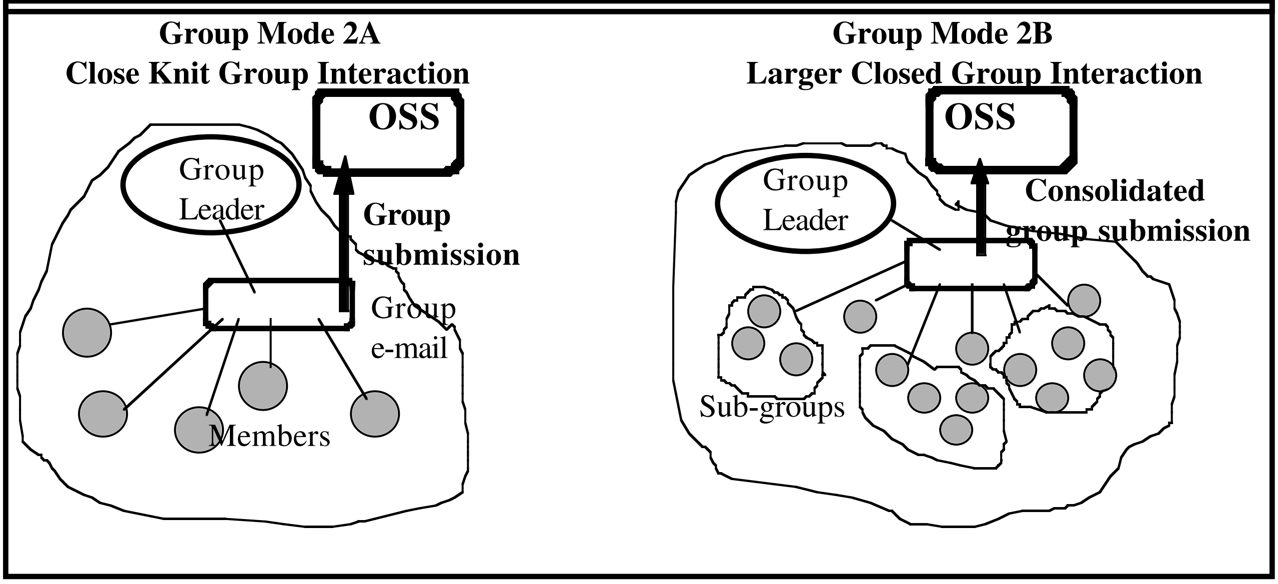

Fig 2 Close Knit Group local context and the modes of use of OSS

Larger groups, often consisting of several factions or sub-groups (Group Mode 2B, Fig 2), also submitted a consolidated group response, but spent more time and effort in negotiations. Irrespective of the size though, close knit groups tended to perceive the Consultative Process as a new threat to their autonomy, as an intrusion into their own business and their professional responsibility. They perceived the OSS not as an opportunity for a University-wide debate and engagement with the broader community, but as a means to more effectively promote their values and protect their group interests.

3.1.3 Open, Democratic Group Culture

A lot of groups exhibited an open, democratic and participative local culture (Fig 3), encouraging
loyalties toward both the group and the University. They not only engaged in the consensual processes within the group but also actively promoted and battled for participative and democratic ideals within the University. Most of the active participants (apart from the Executive) in the Consultative Process came from these groups. The availability of information and the transparency of the Consultative Process achieved through the OSS made them feel empowered and better prepared to take a critical approach.

Characteristics of the local context

- open, democratic, and participative local culture encouraging both loyalties toward the group and the University
- active engagement in the consensual decision making and collaboration within the group as well as in the promotion and affirmation of participative and democratic ideals within the University
- information and knowledge shared within the group and a broader University community

Group Mode 3
Open Communication Within and Without

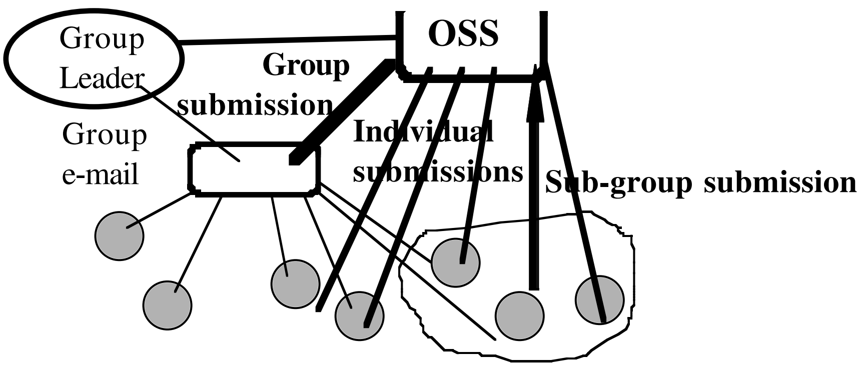

Fig 3 Open, democratic local context and the mode of use of OSS

These groups used the OSS according to their ideals of an open and democratic process. They used the full potential of electronically mediated communications to engage in the University debate, to hear from others and to be heard. They experienced many benefits reported in the literature: equality of access, softening of status related barriers, and decrease in their physical and emotional distance from the Executive and from other fellow members.

3.2 ORGANISATIONAL LEVEL

3.2.1 Top-Down and Bottom-Up Hierarchical Interaction Process

Characteristics of the organisational context
• top Executive acting as brain and mind of the organisation, responsible for its performance • top down, hierarchical process; information flow from the Executive at the top downwards to the members • legitimation of organisational knowledge based on the authority of power

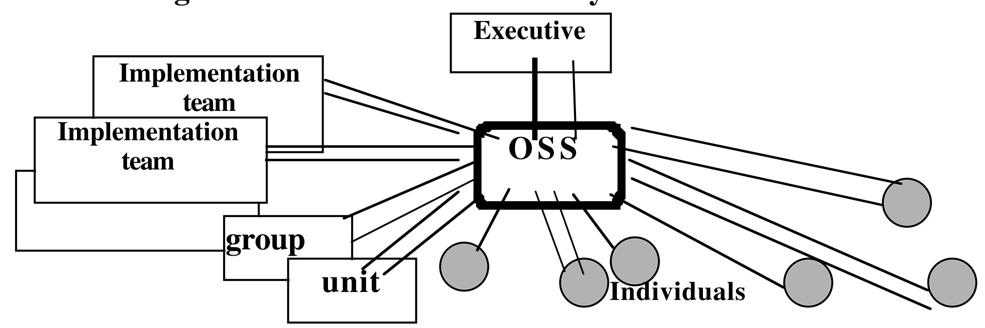

Fig 4 Hierarchical, two-way interaction context and the mode of use of OSS

At the very beginning, the Consultative Process was conducted as a top down, hierarchical process, characterised by vertical flow of information from the Executive to the members (Fig 4).

This use of the electronic media by the Executive to disseminate information was perceived by some interviewees as an exercise of the authority of power. The feedback from the community was nevertheless triggered as each member of the University and all the departments, units, groups were invited to respond. A public two-way vertical communication had been established (Organisational Mode 1, Fig 4) and towards the end of Phase 2 intensified. The OSS was instrumental in achieving the two-way communication between the Executive and the members of Sygma. Some interviewees found it democratising and contributing to the more participative decision making. Others, less enthusiastic, found the interactions “controlled and carefully managed by the centre”, “diminishing the origins of potential resistance and taking control of them, appropriating them”. Although technically enabling an **n:m** interaction, the OSS was perceived as a means for two-way communication, between them and the Executive, not as a dialogue among the members. This mode of use of the OSS reiterated *vertical flow of information* typical of bureaucratic and hierarchical organisations.

3.2.2 Collaborative Interaction Context

The turning point in the use of the OSS, and in particular the Intranet, was an agreement at the beginning of the implementation planning process that documents might be published electronically in draft form as they were created or changed, without necessarily being officially approved. Despite the strict policy that required Presidential approval of any official document, consistently applied prior to this point, the major Implementation team (chaired by the President) admitted that the sheer volume of documents in circulation and the dynamics of their creation and refinement made the policy unrealistic. Instead, divisional teams were encouraged to share their draft documents via OSS, so that others could learn about them and check if there were any problems (inaccurate assumptions about another division, its tasks or responsibilities, possible inconsistencies of solutions, proposed policies, procedures, etc.). The culture of sharing ideas with others and collaborating on the critical issues was gradually developing (Fig 5).

Characteristics of the organisational context

- more flexible, less hierarchical structures and relationships in the Phase 3 of the Consultative Process
- authority of power positions in establishing organisational knowledge declining; increasing sharing of information and knowledge across the University
- development of collaborative culture among members of the University

Organisational Mode 2: Collaborative Interaction

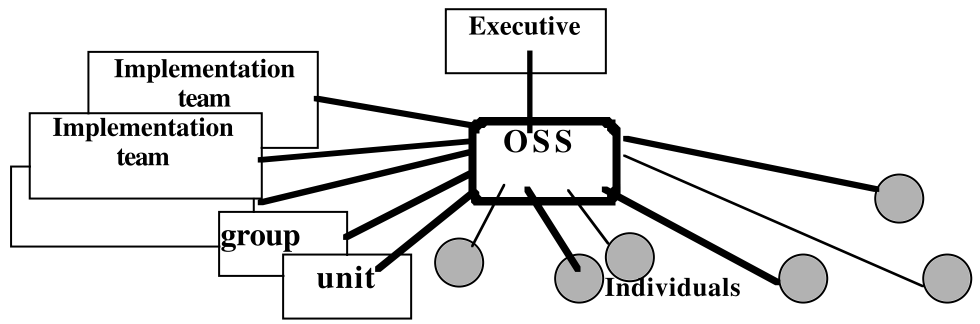

Fig 5 Collaborative interaction context and the mode of use of OSS

Compared to the previous phase, the mode of use of OSS has changed: various teams and groups used OSS more and more for lateral communications, knowledge sharing, and collaboration. The process of creation and refinement of documents within an implementation team and interaction with other teams, groups and individuals via OSS was accepted as a <u>knowledge legitimation process</u>. Interestingly the participants in this process found themselves in control of what was established as organisational knowledge despite the fact that it was contingent upon the President's final approval.

4. CONCLUDING REMARKS

From a technological point of view the OSS provided equal opportunities for access and contribution to organisation-wide decision making, as well as equal chances to interact with and influence others. These same technologically enabled opportunities have been perceived, interpreted, and used in many different ways across the institution. OSS was used as an instrument to reinforce the existing interaction patterns, the authority of power, and status related differences, thus reproducing the existing value system and management structures. These findings are in line with the research results by Birkson et al., 1989, Rice (1990), Child and Loveridge (1990), mentioned earlier. On the other hand, the OSS helped some individuals and groups escape existing hierarchical structures and bureaucratic relationships and have their voice heard. Many also used the OSS to interact with others and engage in a discussion irrespective of their status and rank. This is consistent with findings of Sproull and Kiesler's (19911, 19911b) that electronically mediated communications foster democracy.

The vast difference in use reported in the literature and also found in our research, can be explained by significant differences in the social, cultural and organisational environments within which the technology was embedded. The deep analysis of the local contexts (units, departments, groups, teams) on one hand, and the organisational context, on the other, revealed an essential role of the following contextual features:

- Subordination and obedience to superiors, lack of trust, dependence on authority, autocratic management style using monitoring, control and reporting, typical of hierarchical and bureaucratic systems, produce a climate in which superiors legitimately use the technology (as any other means) to reinforce their power position and in which subordinates suspect that this might be the case. We do agree here with Mantovani (1994) that the technology is adapted to the "uniqueness of the social context". In other words, the mere opportunity for equal access and freedom of speech (technologically feasible) is not sufficient to change a non-democratic, authoritarian context to become a more democratic and participative one.
- Questioning, disapproval and rejection of existing power structures and the legitimacy of power motivated some members to use the technology as an instrument to escape the established bureaucratic constraints and voice their opposing ideals, values, and norms. They used the technology strategically to influence others, particularly top management, with the aim to change either their local context or the broader organisational context. This may be interpreted as having a democratising impact on the interaction patterns. Note however that the technology in these cases did not affect the established power structure nor did it affect the role of the authority in legitimating organisational knowledge.
- A high level of trust, mutual interdependence, the authority of knowledge and the climate of collaboration and cooperation, information and knowledge sharing, characteristic of democratic and participative management systems, seem to ideally match the technology like the OSS. Although this management model was rarely present in its full colours, or at best is found in pockets (groups, teams), we still learned a great deal from the changes realised by the use of the OSS. The OSS helped those individuals and groups that were committed to the democratic management values and a participative decision making. Essentially the use of OSS enabled them to actively participate in the creation, sharing, and legitimation of organisational knowledge. In such a subtle way the OSS contributed to the fundamental changes in the control of communication channels and mechanisms by which organisational knowledge is established. These changes, we believe, are potentially extremely powerful in affecting the painful transition from the bureaucratic, authoritarian type of organisation to a more democratic and participative one.

Our case study demonstrates how qualitative research can contribute to the understanding of particular social, cultural and organisational contexts that conditioned complex interactions among the actors and the technology (an Organisational Support System in our case). It enables us to uncover and understand multiple contextual factors that affected different perceptions and interpretations of the OSS's purpose and role, different ways of appropriation of the OSS relative to the individual or group needs, interests, and position, as well as different implications on the particular contextual conditions at the group and organisational level. The lessons learned should be of interest to both the designers of technologies to support organisation-wide decision making processes and organisations that implement them.

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INFORMATION MANAGEMENT AND MULTICRITERIA METHODS IN A CONTEXT-SENSITIVE DECISION AID

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Abstract

Operational tools can be introduced into a real decision process to support its different phases if a clear understanding of the multiple complexity elements that can characterise the problem situation allows an intelligent and integrated use of valid tec hniques. The mainelements that characterise the context complexity are presented and put in relation with some typical decision situations which can be faced by a technical approach. Some technical possibilities of consistently providing decision support with the context complexity are discussed.

Keywords

Context complexity dimensions, multicriteria evaluation, technology support.

1. INTRODUCTION

The understanding of which context an analyst is working in is essential for a correct intervention. Reasoning about co ntext is essential for the choice of a consistent approach, the identification of a usable method and the correct use of this method, mainly in terms of decisional parameter modelling and choice of interactivity and sensitivity analysis procedures.

Problem formulation and structuring is an essential action that should precede each technical choice, in the analyst's technical intervention and also in the structuring and developing of an effective DSS. The context understanding, in the initial analysis and testing of the information system related to the problem situation, can have a strong influence on the two technical contexts. This information system is constituted by elements of a different nature and from different sources and it is strategic to unde rstand the situation and then to support each technical action in the intervention process. The same structured knowledge can improve the effectiveness of a consistent DSS.

A system which includes and makes all these different information elements usable m ay support problem and context understanding and may orient the definition of a specific course of action and the correct integration of different tools, to reduce uncertainty and context criticality. A system, which can use all these different informatio n elements, may be more flexible, in terms of technical integration with different environments, orientation to the user and the user's problem, analysis of the market and its tendencies.

An analysis on the relationships between context, knowledge organisat ion and definition of decision situations is presented in this paper in which the second section describes a scheme of context analysis, key element modelling and main situation identification. The decision situations that can be faced by a technical appr oach (and more precisely by a multicriteria approach) are presented in detail in the third section and the relationships between these situations, their main factors and the different technical actions is analysed in the last section.

2. CONTEXT ANALYSIS

Context understanding is essential for a correct intervention and this activity, in the initial analysis and testing of the information system related to the problem situation, is oriented to recognising the specific organisational, process and operation al context and the multiple complexity elements which can characterise the problem situation. The main elements proposed in literature and here recognised as significant and sufficient to elaborate an operative framework, are synthesised in a scheme an d are related to three dimensions: *organisational*context, *process* contextand *technical and operational complexity.* Flood and Jackson (1991) using the organisational and the complexity dimensions propose a categorisation of problem contexts with the aim of grouping the different systems methodologies and suggesting when a situation favours the use of one rather then another. Here the two dimensions and the third processual dimension are presented with a similar aim of recognising and grouping situations in which a specific technical approach can be used and precisely oriented to the situation.

2.1 Organisational and process context

The first micro-dimension is related to the *organisational*context which influences the decisional situation and the technical action. Some methodological approaches have been proposed in literature to distinguish the different situations and adopt consistent courses of action (see for instance Bowen, 1983; Osta nelloand Tsoukias, 1993). In a real synthetic way three typical situations are recognised and indicated as a *stable and unitarian*state, a *stable and pluralistic* state and an *evolving and pluralistic*state.

The first state identifies the most advantageous situation for the analyst, in which the problem is seen from the only and stable decision maker's point of view and, if the solution derived by a method is accepted, implementation is assumed to follow. The second state is related to a situation in which several groups of people or stakeholders are involved with differen t roles and each of them proposes a different way of viewing and interpreting the problem situation based on his or her background, experience, training and values. The situation can present a different complexity (in terms of conflict level and number of the involved stakeholders and of their perspectives and objectives), the only positive aspect is the relative stability of this situation, which implies time margins to analyse and face the problem. The last state proposes a pluralistic and evolving orga nisational context which implies clear difficulties for the analyst.

The second macro-dimension is related to the *process*context that characterises a situation in which problem formulation, involved actors, "means" , data, information, knowledge and preferences evolve continuously. A technical action should evolve during the intervention in terms of the main purpose, method ological approach, choice and use of appropriate tools; a DSS should memorise these evolving situations and allow an easy passage from an information and decision state to a new one, from old to new problem formulation, possible courses of action and decision criteria.

Three different states are defined as *pre-decisional, decisional*and *post-decisional* context in order to synthesise the different elements which can characterise the technical actions in relation to a decision process. In the first state the intervention is mainly oriented to understanding, analysis and problem structuring; time limits ar e not so restricted because each decision is not imminent. In the second state the problem situation should be sufficiently clear and well structured, or it still has to be analysed but the technical action is defined and may be urgent. In the last situation at least one decision have alread y been made, but the resources have to be identified and mobilised and the decision implementation has to be supported and managed.

2.2 Technical and operational complexity

The third and last micro-dimension is defined as *technical and operational complexity*and includes a multiplicity of elements that characterise and limit the operational context in which every technical course of action develops. They can be distinguished as *information, actors'* and *environment characteristics*, which are articulated in five criteria, each of which joins to different qualification states (Roy, 1985; Vincke, 1992). Combinations of these states (one for each criterion or attribute) identify different *technical and operational complexity* situations.

Information characteristics
Two main complexity forms (*orientation and understanding complexity*) characterise the information situation. Elements of a reference system (points, co-ordinates and categories) allow the course of action to be oriented; the nature and conditions of this reference system can be different and the possible analysed states are: Total absence of a reference system (ARS), Presence of a restrictive reference system (RRS) and Presence of a limited reference system (LRS) which is not restrictive and can be improved or modified by a technical action. The first state is especially critical because there is no particular idea of how the problem has to be faced; the second state (RRS) proposes the opposite situation in which a clear reference system imposes great constraints and sometimes limits the view. The last state (LRS) is the most favourable because the reference system can guide the action without a strong restriction.

Information elements on the organisation and the specific problem situation can be globally or partially lacking and may require specific inquiry activities. Three main situations are analysed in terms of Total lack of information (LI), Constraints in the use of previously acquired information (CI) and Imperfect information (II). As in the previous situation the first state is especially critical, the second proposes a differently critical situation and the third represents a normal situation.

Actors' characteristics
Decision complexity is related to the nature of the decision system. Three states characterise this system as a conflict or coercive (Flood and Jackson, 1991) situation (C), a scarcely relational situation (SR) and a co-operative situation (CO). The first situation is the most critical, because conflict views reduce the margins of a technical action. The second, in which a lack of communication can be technically solved, but it may be the sign of latent conflicts, is relatively less critical. The third situation is the most favourable, because a co-operative approach implies different points of view, but also an inclination to debate and negotiation.

The *perspectives on action* in an organisation characterise the problem and impact the technical approach. External and internal critical factors can generate a crisis situation; positive stimuli and internal interests can generate opportunities (Mintzberg, 1976; Pettigrew, 1990). In the "rational actor" perspective, people and organisations evaluate alternative courses of action and exercise free rational choices; in the "situational control" perspective external factors or events constrain or force people and organisations to behave in certain ways. In the "emergent" perspective on action, the behaviour of people and organisations emerges from a dynamic interaction of external circumstances and internal motives of interests (Pfeffer, 1982; Markus and Robey, 1988). The adoption of the first approach (RA) implies that the problem is well structured and information is available, complete and usable. This approach becomes dangerous if the situation is different. The second state (SC) implies an organisational passive attitude towards each risk situation and a very attentive technical intervention. The third state is the most favourable for each technical course of action.

Environment characteristics
The nature of the environmental stimuli to the problem situation characterises and limits the operational context. They can be critical factors which are external to the organisation (CEF), internal critical factors (ICF) and internal stimuli and advantages (ISA). The first two states propose critical situations, the last state is completely different.

2.3 Classification schemes

The combinations of all the different qualification states, for the five criteria, identify 243 different *technical and operational complexity* situations, but not all these are possible and significant. In (Norese and Macciò, 1997) all the situations were analysed and ten sets were excluded because they were impossible (3 sets), improbable or without any mea ning (7). The remaining 67 possible situations were classified into nine typologies, in relation to the main critical factors or simple constraints, and then ranked in four macro-levels, in terms of criticality and complexity (*simple, difficult but under control, very complex and critical situation*), which characterise the operational dimension (fig.1). These four states must be connected to the three situations (*stable and unitarian* , *stable and pluralistic*and *evolving and pluralistic*) which are indicated in relation to the *organisational*contexts and the other states (defined as *pre-decisional, decisional*and *post-decisional*) which characterise the *process*context. Twelve different contextual situations are recognised (fig.2), in relation to the organisational and operational dimensions, and these acquire more detailed distinctions when they are related to the decision process evolution and the operational finalities and time limits which characterise each phase.

If attention is concentrated on *evaluation*, the context analysis can underline specific elements which condition the evaluation development. In some situations the definition of an evaluation procedure is quite impossible; in others, when the recognised complexity is acceptable and clearly charac terised, the support of specific techniques is required to reduce the critical conditions and allow the evaluation development; the content of an evaluation, that is, the values and criteria to be considered and what should be measured, changes with the specific context situation. In the next section the different evaluation conditions in the various decision contexts are examined, mainly in relation to the multicriteria approach and to its methods and procedures.

The relationships between these situations, their main factors and the different technical actions are analysed in the last section and connected to a new generation window-based environment which allows the processing of structured data, images, documen ts, graphics and voice).

Macro-levels	**Typologies**	**67 possible situations**
Critical situations	Urgency, conflict and innovation (crisis) Urgency and conflict Conflict	3 4 6
Very complex situations	Urgent and without any reference situation Urgency Inconsistent decision approach Restrictive reference or information system	4 14 6 4
Difficult but under control	Information and decision constraints	24
Simple situations	Structured problem, without information and decision system limits	2

Figure 1: Operational dimension macro-levels.

3. EVALUATION AND MULTICRITERIA AID FOR DECISION

Evaluation is a complex and elusive notion that has a number of overlapping interpretations. It is an on-going activity, which is always present in a decision process; the contents and form of the evaluation change in relation to the specific phase of th e decision process, to its nature and to its main purpose. Evaluation can be seen as a process and at the same time as an important decision support function; it may be defined as a collective learning pro cess which links evaluation contents (that is the values and criteria to be considered and what should be measured) with the evaluation context (Serafeimidis and Smithson, 1996). The evaluation can be considered as a process for diagnosing malfunctions an d suggesting appropriate remedies as well as contributing to the planning of organisational activities. From a system’s perspective, evaluation is the crucial feedback function, which helps the organisation learn and which helps managers to plan and control their investments. From a management point of view, evaluation is a process oriented to establishing the value of an object (or a project, a candidate, an idea, a course of action and so on) for the organisation.

This last interpretation is the core of methodological approaches which focus on values and alternatives to solve decision problems (see for instance Keeney, 1992) or on the multiple consequences of the possible actions-decisions, seen as application poin ts for decision aid (Roy, 1996). This las t, the Multicriteria Aid for Decision, is a discipline oriented to support decision processes in different organisation contexts, using a multicriteria approach and evaluation multicriteria methods. These methods are flexible enough (and numerous enough) to be used in different contexts, but the choice of a specific method and the correct use of a method (mainly in terms of decisional parameter modelling and choice of interactivity and sensitivity analysis procedures) are closely related to the context.

Theevaluation process develops and assumes different roles and meanings in relation to the organisational and operational peculiarities of its context. In the classification scheme of fig.2 twelve different contextual situations are recognised in relation t o the context organisational and operational dimensions. Situations II, III, IV and VIII cannot be faced by a multicriteria approach and evaluation multicriteria methods because of their great conflict or evolutive nature. Situations I and XII are not rea listic or not significant. The other situations, which may be faced by a multicriteria approach, are defined as:

〈 multiplicity of homogenous point of view (situations IX, X and XI);

〈 multiplicity of non homogenous points of view in a general attitude to co-operation and negotiation (situation V);

〈 multiplicity of non homogenous points of view from non collaborative involved actors (situations VI and VII).

These three macro-classes acquire more detailed distinctions when they are put in relation to the decision process evolution (and then to the operational finalities and resource/time limits which characterise each phase) and to some important elements that characterise the decision process and impact the evaluation content, such as the structuring level of th e problem situation, the multiplicity and interdependency level of the problem situation issues, the initial definition level of decision alternatives and criteria and the information state. Some different global contexts may be proposed, three of these a re here described because of their great influence on the way of thinking and developing an effective DSS.

A formal multicriteria model and a multicriteria method
When the problem situation, the model (in terms of decision alternatives and criteria) and the information state are at least partially structured, the decision process state is generally *decisional.* In the presence of homogenous points of view, the operational dimension first macro-class identifies the contextual situation which can globally be defined as relatively easy (situations IX and X) or rather complex, but only in terms of urgency or information restriction (situation XI). Several evaluation multicriteria methods can be used and the choice of a method is mainly related to the problem s tatement definition (*choice, sorting*and *ranking problems*(Roy, 1985) to determine a subset of actions considered to be the best with respect to the family of criteria, to divide a set of actions into subsets according to some norms, to rank the actions f rom best to worst) and to the specific information state (accuracy or uncertainty of the data). The presence of homogenous points of view means that each decisional parameter is easily modelled and a plurality of parameters are defined with the aim of a s ensitivity analysis.

If information is not partially but completely structured and binding (RRS and CI as Information characteristics, cf. 2.2),the situation can become difficult when the information structure and quality are not consistent with the method requirements easy (situations X and XI).

If the context situation is characterised by a multiplicity of non homogenous points of view (situations V, VI and VII), even when a general attitude to co-operation and negotiation is shown, the deci sion process requires a collective validation of both the conceptual model of the problem situation and the formal model (Landry et al., 1983) and then, if they are globally acceptable, passage to a method. The collective validation of a partially struc tured model should be supported by a very flexible system, such as those proposed in (Belton, 1985 and Friend, 1989).

_Operational _dim. Organisational dimension	Simple situation (Well structured problem without information limits)	Difficult but under control (Information and decision constraints)	Very complex (Urgency, decision and information system restriction)	Critical situation (Urgency, conflict and innovation)
Evolving and pluralistic state	_Conflict (I) Not realistic	and_evolving (II) No MC	situations (III) No MC	_(IV) No MC
Stable and pluralistic state	Non homogenous (V)	_points_of (VI)	view (VII)	(VIII) No MC
Stable and unitarian state	_Homogenous (IX)	_points_of (X)	view (XI)	(XII) Not realistic

Figure 2 Contextual situations.

A formal multicriteria model as an "evolutive" system
When the problem situation, the model and the information state are ill-structured, the decision process state is generally *pre-decisional* and the intervention is mainly oriented to understanding, analysis and problem definition and structuring. The contextual situation is frequently related to the stable and pluralistic state and, when it is identified by the first or the second macro-class of the operational dimension (situations V and VI), specific techniques should be activated for each class to reduce critical conditions and uncertainties and allow more detailed characterisations. Different approaches and tools have been proposed in recent years (see for instance Lendaris, 1980; Bowen, 1983; Kling, 1987; Rosenhead, 1989; Rohrbaugh and Eden, 1990; Basadur et al.,1994; Buffa et al., 1996). Some of these have been oriented to specif ic aims, such as problem identification, formulation and structuring, while others have been more concerned with the global management of problems and models (for a critical review see Baldwin et al., 1991). Some of these tools are proposed as Decision S upport Systems (see for instance Eden and Radford, 1990; Jelassi et al., 1992), others are rather methodological and technical tools. The initial perception of the situation complexity should orient in adopting a correct approach and a specific technique. The integration of some key tools in a context-sensitive system could be a useful answer to the multiplicity of ill-structured situations and the only possibility of supporting a formal modelling phase.

A formal multicriteria model has to be developed for t his situation as an "evolutive system" (Ozernoy and Gaft, 1977; Schneeweiss, 1987; Ostanello, 1990) which is based on different elements, such as the problem statement, the set of actions and the family of criteria, which change during the process. Often none of these elements are known at the outset of the modelling process and different analysis and modelling steps have the main task of element identification or elaboration and making these elements operational. It rarely happens that the actions and c riteria of a decision problem are objective realities which are easy to grasp and model. Multicriteria aid to decisions implies that the scientist, before attempting to apply a method, should help the decision-maker to define these elements, and the latter may be one of his most arduous tasks (Vincke, 1992).

Innovative situation and collective action on the models
When the problem situation and the model are ill-structured and any information element is absent (ARS or LI as Information characteristics, cf.2. 2), the decision process state is generally *pre-decisional* (*post-decisional* when the decision implementation is difficult, new for the organisation and object to structuring and planning) and the contextual situation can be identified in relation to different situations, with a growing level of difficulty (situations X,VI, XI and VII); the situation can be defined as innovative and the intervention is oriented to the management of new ideas and procedures, but mainly to acquiring information elements. This implies an individual and/or collective work on the possible model elements, which are developed by interacting with different logics of action and the several representations of the involved actors, exploring each possible information element, acquiring information and redefining it until an acceptable level of stability is obtained. This implies the employment of techniques and tools which can facilitate discussion and explicit negotiation of the significant

problem elements, enabling the structuring o fdifferent courses of action and their assessment and control. Effective and efficient modelling requires a great deal of expertise and is generally not supported by well structured tools. A model should include all the significant points of view on the pr oblem and a clear specification of each element; its structure should be simple, easily understandable and rigorous.

Each situation needs specific capabilities, of non homogenous data handling in interconnected databases, significant information selection, graphic display of the results and direct use of selected data as input for a method, without any specific interface program. The growing level of difficulty of the identified macro-situations implies other possibilities such as use of hypothetical infor mation elements in addition to the others, combination of hypothetical and real information elements to determine possible scenarios; complex searches in the database with ranking of the results, management of complex element classes where reliability, sa tisfaction, sharing, etc., are connected to information; data analysis by hypertextual navigation, similarity analysis on the database information.

The possibilities for providing decision support, consistently with the context complexity, are now almost a reality. Some of these are discussed in the next section.

4. SUPPORTING TECHNIQUES

The need of translating facts, proposals, points of view and preferences into formal models, where mental, written and numerical data, from different sources, are orga nically synthesised, is common to each of the analysed situations. This is not a novelty. In the 1980's research mainly focused attention on the hypothesis that data, knowledge and inferential capacity were the basis of a DSS. In this context there were t wo most important aids the system would have to provide: analytical capability and data management. The advantages of non procedural manipulation and inferential retrieval (Bonczek et al.,1981) were emphasised versus the limitations of procedural manipula tion. The use of graphical user interface and facilities (such as report generation and graphic production) were overvalued. A correspondence between the relational view of data and models were also hypothesised (Blanning, 1987).

The 1980's approach was also characterised by an attempt to directly find decision problem solutions by means of the tools and the opportunities that the market supplied (window interfaces, expert systems, hypertexts, information retrieval and so on). Whe n, for example, conventionalDBMS were only able to handle facts in the form of relations and tuples or in the form of files and records, the expert system approach attempted to overcome this limitation because the essential knowledge in a DSS could no longer be described only with facts.

In the opposite position and over the same years, the ideas and requirements of the DSS researchers were acquired in the context of design and development of information management systems. An example is QuerySys (cf. Marzano et al., 1993; INSI EL, 1993), a data management system which was developed in the early 1990's for the purpose of full text management, but was then experimented in a multi-actor context as a Decision Support System. Texts are not the only information type in a DSS, theref ore QuerySys evolved towards the management of other data, such as structured data, images, graphics and voice. From a document management system it became an information management system. The QuerySys environment now integrates three different paradigm s of data management: DBMS for processing structured data, information retrieval for processing full text data and hypertext for browsing and linking different *chunks*of information. QuerySys manages unidirectional and bi-directional links between data objects belonging to the same or different databases. A label can also be associated to a link and can be used to retrieve and browse over the data objects which share the same label. This feature was used in (Buffa et al., 1996) where the main database conta ins complex data objects formed by full text data, structured data and links and each data object corresponds to the stereotyped representation of a single main problem or a specific sub-problem of an unstructured and multi-actor problem situation. QueryS ys link management function was used to build the Actor Structure Network and to link the items of the main database to *chunks*of information stored in the support databases. The Actor Structure Network describes the relationships between each individual or collective actor who is recognised as being an information source and/or a key stakeholder in the past, present or future decision processes and is quoted in the main database in terms of main elements that characterise the actor's position in relation t o the problem situation and the decision context and process. The relationships can be made explicit in a logic and graphic way.

The external links, which are posed between the main database data objects and the items belonging to the support database are also very useful, and make it possible to obtain information from other specific databases by means of the reference contained in an item of the main database. An unlimited number of support databases can be used. Since the program adopts a multi-document approach, it is possible to open various search sessions on the screen at the same time and simultaneously visualise information from different databases. A search session is a window containing information retrieved by means of a sequence of queries. Th e system also offers the opportunity of collecting, storing and saving the outcomes selected from several search sessions.

The full text search is also an important facility used in (Buffa et al, 1996). It is easy to obtain access to the data objects by using the keywords contained in the full text fields. Each word of the text is a keyword, with the exception of those that appear in the stopword list. The user can specify topics of interest through a query so that the system can find data objects that dea l with the same topics. Keywords are also combined using Boolean operators to specify topics for a query. Links can then be established between the data objects that satisfy a given query.
In relation to this last opportunity, the system should again develop to connect the actors in a decision process and manage different knowledge forms, in relation to the pre-decisional state requirements. The new query form, in addition to the others in use, is characterised by a dialogue window where the user can indic ate whether the full text search has to be made on a specific field or on all the full texts (fig.3). The query words can be filtered by the elimination of : stopwords, less then three character words, ciphers and words that are characterised by a less or greater

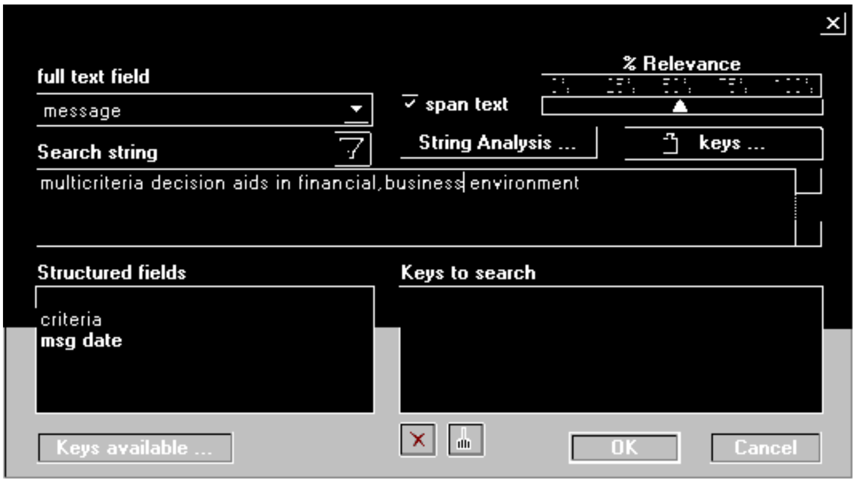

Figure 3: Query form.

Figure 4: Relevance assignment: first modality.

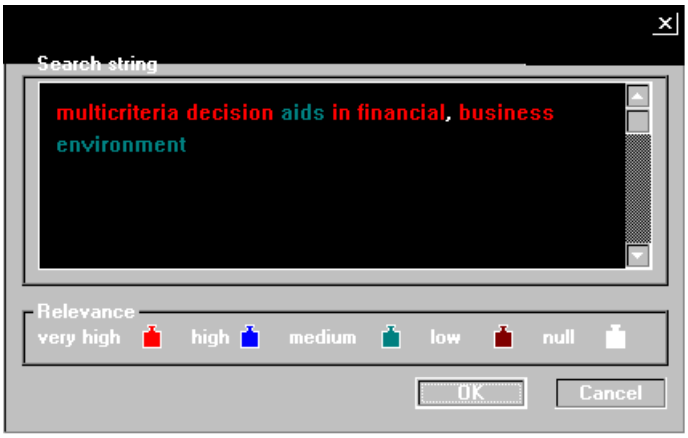

Figure 5: Relevance assignment: second modality.

then a specific threshold frequency. A statistical ana lysis can be developed to determine a correct and specific threshold value. A relevance value can be assigned to each word in the query and memorised. Two different modalities can be used. The first calls the list of the word values which have been memori sed and then changes the values interactively (fig.4). The second modality implies that the values are changed on the query text, which is presented in the dialogue window (fig.5). The query words assume the colours which are relative to the assigned valu e.The relevance values can be: very high, high, medium, low and null. QuerySys allows the search outcomes to be saved in folders. In QuerySys, a folder is a window in which it is possible to collect and store records. Belonging to a database, copies of rec ords can be transferred to a folder, which can receive a name, can be saved on disk and recalled. A folder can contain any number of export windows, as long as they are compatible with the available memory resources.

5. CONCLUDING REMARKS

Context under standing is essential for a correct intervention mainly when it is oriented to recognising the multiple complexity elements which can characterise the problem situation and limit each technical course of action. Process evolution goes together with the un derstanding of different contingent situations that evolve in terms of problem formulation, actor structure and information requirements and processing. The different approaches and points of view of the involved actors, in the context of work, induce lim its in the technical approach besides conflicts in the global course of action. This criticality implies choices (of a communication language, a methodological approach, a class of acceptable methods, etc.) which are similar to the choice of an Information System environment for an effective DSS.

Technology continuously progresses and the technical possibilities for providing decision support more consistently with the context complexity are now almost a reality. The growing complexity of situations, which t he analysts wish to face, induces new complexity in a supporting system and this system risks becoming so complex (and lost in an ocean of details) that it cannot be managed. A strong control on the nature of the effective Decision Support Systems main r equirements should reduce this risk.

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UTILIZATION OF DATA OF NATIONAL STATISTICS IN THE PROCESS OF DECISION MAKING

Toma_ Banovec, Niko Schlamberger

Abstract

The paper deals with general problems of decision making. For a decision to be made, there are three entities involved. Data is generally recognized as a necessary prerequisite to come to a decision. Next to data, an adequate model to deploy the data is needed, and both data and model must be considered within a relevant time interval. All of the three put together provide grounds for a correct decision. As the present methods allow to decide upon the correctness of a decision only afterwards, the authors propose that instead of the term "a correct decision", the term "a probability of a correct decision" be used. Further, they also introduce a concept of a provably correct decision. To this end an impartial method should be devised to help extract relevant information, relevant knowledge, and relevant time frame to construct a particular decision function for a particular situation.

State and political decision making is treated further in the paper. Decision making is probably one of the few generic functions of every government. For its impact on all of the subjects and very often also international consequences, it would be desirable to have a method for producing provably correct decisions. For this, impartial, nationally normalized and internationally harmonized data is required. In most cases it is provided by national statistical offices. Categories, use, and importance of statistical data are presented, and it is proposed that for state decisions, impartial and transparent methods be used. The authors believe that semi-quantitative models would greatly improve the process.

1. INTRODUCTION

One of myths of information sciences is that of the correctness of decisions based on appropriate information. Yet, in history, not to speak about personal experience of every individual person, the authors included, there is plenty of examples of wrong decisions even at having all the necessary information at hand. More rare and more surprising are cases where decisions were correct although based on irrelevant information. Probably the most illustrative example of such decisions is the life story of an American millionaire Timothy Dexter, who lived at the beginning of this century. The story deserved to be told in more detail, but just to summarize -- he was a joke to the business world of the New England of his time, and most of his moves were laughed at. Surprisingly, by each one of them he became all the more rich [1]. How can this be? An obvious answer to the question is that besides the relevant information, something else is required for a correct decision. For this reason, the statement about relevant information as a basis for correct decision is an oversimplification and thus deceptive. Information (or data) is a necessary, but not sufficient condition for a correct decision.

The categories dealt with in the paper are known, but nevertheless let us define some of them that are used further in this paper, knowing at the same time that for every one of them, even tens of definitions have been offered and used.

A system is a *hierarchical* aggregation or assemblage of objects joined in some regular interaction or interdependence *in order to perform a function*[1]. They are composed of *entities* which are described by *attributes* and which execute *activities*. For the purpose of the paper, it is convenient also to offer a classification of models[2] (Diagram 1).

A model is a body of information about a system or a process, gathered for the purpose of studying [2]. The body of information may be formalized and structured, or unformalized and

[1] Definition as found in [2] and extended; extensions are shown in italics.
[2] Classification as found in [2] and extended; extensions are shown in italics.

unstructured, or a combination of both. Strictly speaking a model is only present if it is being structured and formalized. In this case a model of a system is a valid functional simplification of a part of a system or of a system as a whole. A model is context-dependent as it depends on what part or a property of a system or a process is examined. To test a system, various methods are available. In most cases it is more convenient to test a model of a system rather than the system itself, so a model has to be set up to simulate the real system. A model is tested for its validity by entering data into the model, by observing the data that is the result of operations required by the model, and by comparing the results against the required or desired values [2]. Normally this is done by iterations whereby during the process the model itself may change too.

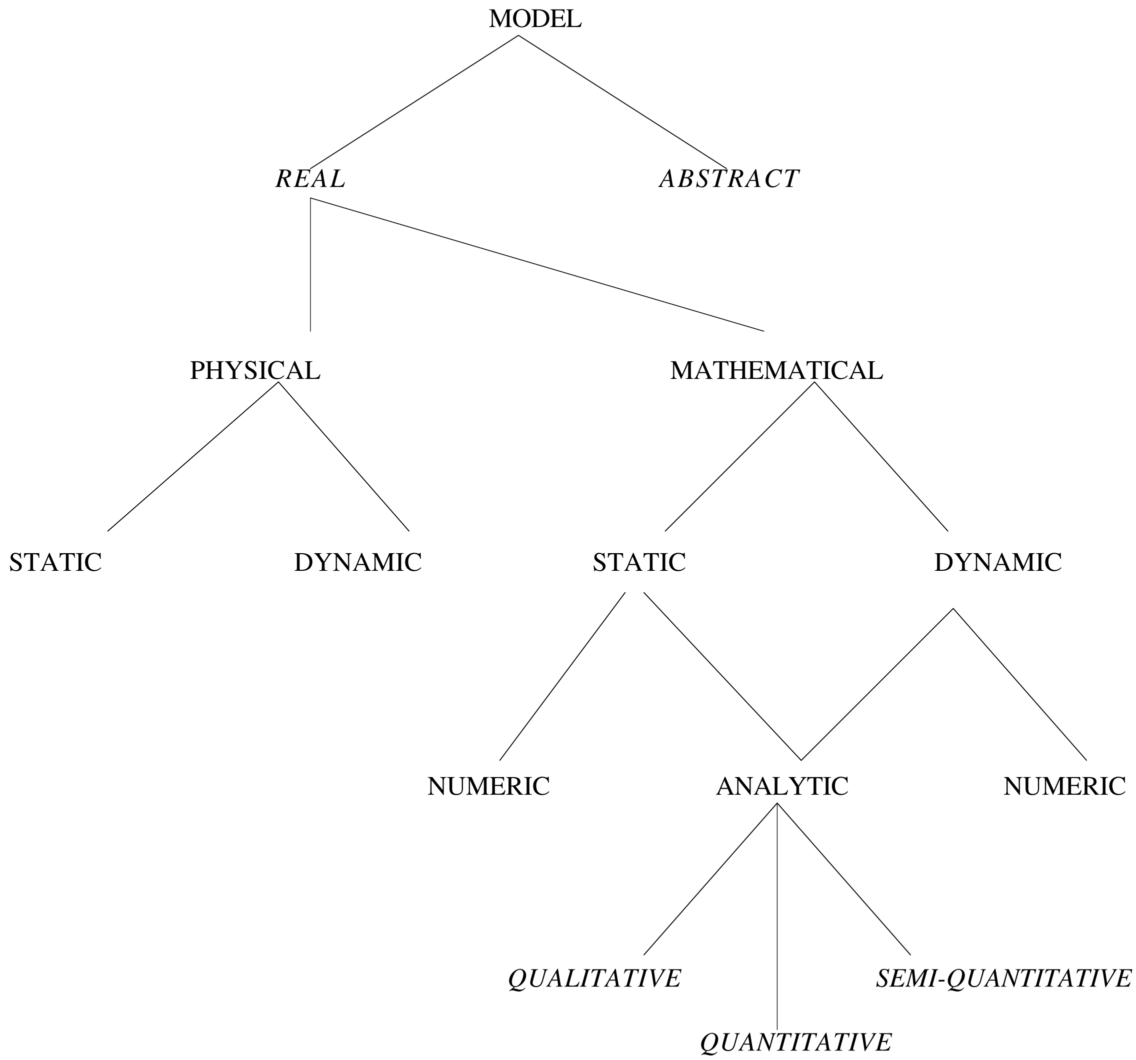

Diagram 1: Taxonomy of models

2. ON MODELS, THINKING, AND DECISIONS

2.1 Correctness of a decision

When studying decisions we are dealing with real situations in real systems and with real consequences. In professional as well as in everyday life decisions are made daily. Undoubtedly, the concept of decision is common and familiar. Also it is commonly agreed upon that

(1) for decisions, information is needed, and
(2) it cannot be certain in advance whether a decision is to be a correct one.

A question is whether it is possible to discuss decisions in general without testing them on special cases. In particular, there is a need to define when is a decision a correct one. To generalize this question, we need first to define a *correct decision*. As a decision is required to reach a goal, let us offer the following definition:

A correct decision is such that has produced the required or desired results in such a manner that goals need not be changed subsequently or that the decision itself does not have to be changed subsequently.

The definition implies that the correctness of a decision can be proved only subsequently, i.e. after the decision has had its effects. Instead of the expression "a correct decision" and "correctness of a decision" it is therefore more appropriate to deal with a *probability of a correct decision*, which may be decided only afterwards. Let the decision function D be a function of three variables: of a model (m), of data (d), and of time (t):

$$D = D(m, d, t).$$

The model itself is depends on goals (g), limitations (l), and rules (r), thus

$$m = m\ (g,l,r).$$

Generally, the goals are agreed upon, the limitations are known and recognized, so that the contextual dependency of a model is brought about by the rules. These vary with the properties of a system that are the subject of study. As generalized problems do not exist, there also cannot exist generalized models. Let it only be noted that models must be somehow formalized, be it in form of a diagram, of an algorithm, of a function, of a structure, or otherwise.

The decision function may be assigned any value from including *0* (a certainly wrong decision) to inclusive *1* (a certainly correct decision). It is rather easy to see the dependency of a decision upon the model and data. Time is the third variable for an obvious reason that the more distant the future, the harder is a correct decision to come by, all other conditions being equal. A probability of a correct decision is more likely when

an abstract model (m) is simple,
relevant data (d) is available, and
the time in question (t) is short.

Knowing this, we now also know the answer to the question asked in the introductory chapter, namely how can this be. Let us propose a matrix containing data and model (for the same time frame, Table 1):

	data	
model	**+**	**-**
+	**+**	**-**
-	**-**	**?**

Table 1: Model, data, and decision

In the above matrix, let + represent relevant data and relevant model, and let - represent irrelevant data and irrelevant model, respectively. The four possible combinations are (+ +), (+ -), (- +), and (- -). Provided that time is the same for all the off them, the combination (+ +) will yield a correct decision, the (+ -) and the (- +) will yield incorrect decisions, and the combination (- -) will yield an uncertain result; in particular, it *may,* surprisingly, also yield a correct decision.

It is commonly accepted that decision making should be studied in depth and that decision making may be improved by using computers. However, there does not seem to be a commonly accepted rationale behind the extensive study of decision making processes and their enhancement with or without a help of software tools. The authors believe that the ultimate goal of studying of decision making should be devising of methods and tools that will enable *provably correct decisions.* To put it simply -- a correct decision is just not good enough. Again there arises the question of a definition, and let us offer the following.

A provably correct decision is such one to which any person, given the same knowledge, information, and time span, would come regardless of the person's individual preferences.

An example of a class of provably correct decisions are proofs in mathematics. Obviously, if we want to even try to come to provably correct decisions, there must first exist a method. A schematic representation is given in the Diagram 2. In any particular situation for a decision to be reached, there exists a body of knowledge from which appropriate subset must be extracted to create a model simple enough to be considered as a relevant simplification of the situation. From the body of information, the relevant subset of data must be extracted to be used in the particular model. From the time continuum, a particular time or a time span must be chosen for which the decision function D will be valid. Provided there existed a *method* to help produce the above, and that there existed a decision function, the decision should be a provably correct one. Unfortunately, as yet there is not a method available to be employed for the purpose. Nor is there a general decision function available, for that matter. Computer programs are not necessarily needed to carry out the scheme into real life. They are useful only inasmuch as to enable us to produce models easier, to extract relevant data easier, and to test models faster.

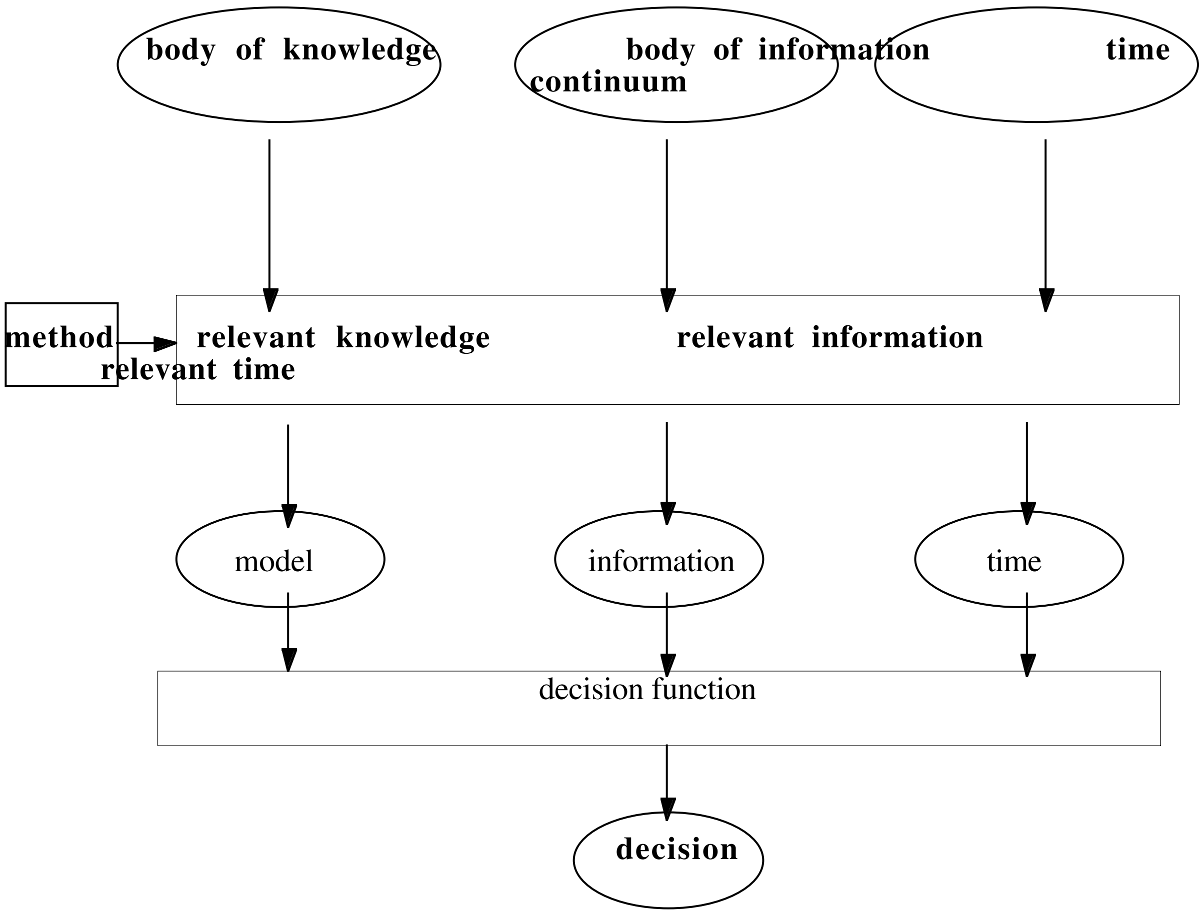

Diagram 2: Elaboration of decision function

2.2. Making decisions

It is common that decisions are reached irrationally and that only afterwards decision makers rationalize, i.e. look after the arguments to support the decision. It is also known that, in order for decisions to be made, there must normally exist motives. No decisions will be made without motive, and many times decisions have to be made under pressure, of which the time is the most known general constraint. All of the above present an environment in which decisions are to be made. To be able to study the process of decision making we shall therefore try not to consider the environment.

We speak of making decisions when there is a task to be accomplished or a goal to be reached. It is not important whether a task is an easy or a difficult one, or whether a goal is near or remote, or whether ways to solution of the problem are known or not. The decision is a final act of a mental process -- of thinking. Act (or acts) follow decision (or decisions). The process is represented in the Diagram 3.

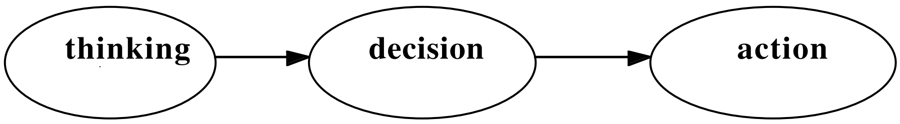

Diagram 3: Thinking to a purpose

In the above diagram, *thinking* is understood as a process of developing abstract models and their testing by means of data and information. The *decision* is the choice of a model, and finally an *action* follows by utilizing real resources. In the above diagram, all three quantities must be present in order to be able to consider a true decision making process. It may happen that one or more of them do not occur. In such a case we are not dealing with a real decision making process. The possibilities are shown in the Table 2:

	thinking	**decision**	**action**
1.	+	+	+
2.	+	+	-
3.	+	-	-
4.	-	+	+
5.	-	-	+
6.	-	-	-

Table 2: Thinking, decision, and action

In Table 2, + and - indicate whether a quantity is in the scheme present or not. Only in the case 1. we may speak about a real decision making process. Case 2. is a case of a useless decision since it is not followed by an action. Case 3. represents a needless thinking as it is not followed neither by a decision nor by an action. Case 4. is an intuitive decision as it is not preceded by thinking. Case 5 is an example of a reflex action that is not preceded neither by thinking nor by a decision, and the last case is void. Only the first case may be considered as complete and thus the matter to be dealt with further. In the scheme, the process of thinking implies that there is an abstract model to be tested. The more appropriate the model and the data, the more likely is that the decision will be the correct one.

3. DATA OF STATE STATISTICS AND DECISION MAKING

State statistics is a very specific case of statistics. It employs recognized statistical methods for purposes of measurement, comparison, and presentation of phenomena in three domains of observation: population, territory, business, and combinations thereof. Methods of determination and saturation of information needs in administration[3] seemingly differ very much from country to country. Still, in market oriented democratic countries rules are quite similar and methods are internationally harmonized through efforts of international institutions (United Nations, International Monetary Fund, OECD, Eurostat), and decision making process is sometimes next to a ritual. Information utilized is mainly resembling, related, and comparable also in terms of methods employed to provide the data. International institutions are normally ready to help to accomplish reconciliation and comparability of common statistical platforms.

It is often so that a considerable portion of information needs of a state sooner or sometimes later becomes represented in programs of collecting of statistical data. The result of this is that national statistical offices (NSO's) support most of traditional collection of national data that is a platform and of importance for domestic users (state and civil services in complete, private sector, household and natural persons, non-government institutions) and for purpose of foreign use and international comparability (international and state obligations such as United Nations and its institutions and others mentioned before; international analysts' groups, forecasters, and related; stock brokers, finance markets, commodity markets, financial institutions, stock exchanges; and other users such as neighbour states, predominant partners, intelligence, and the like).

Government and related institutions are to be understood as responsible holders of common state and civil services for their subjects: businesses, citizens, and their associations. Likewise are to be understood roles of NSO's as those of information services institutions. However, there is a difference between the two in the political power of the state, which may be and indeed should be professional, but is periodically questioned by means of elections and is for that reason in a specific position. To the contrast, the NSO''s normally have an emphasized professional function and a position that is professionally independent of the state and the government. In particular it may come about that statistical measurement of success or failure of the actual government are understood as an arbitratory function and may, although belatedly, even influence elections. Divers ranking of accomplishments of state, their stability, security of investment and similar criteria, introduced by the IMF after the Mexican crisis, are a proof that statistical data and activities of official state statistics are used as a main platform for decisions in those categories.

Most of decision makers on government and other executive levels understand importance of state decisions. In European environment. are extremely important obligations of the EU countries as stated in the proposed compendia. Their volume is huge and virtually misapprehended to most. Each new government tends to begin by creating of a model of metadata bases, so hoping to understand macro data, micro data, and their sources. Some basic statistics and accounts that are of interest to domestic and foreign governments alike are the following:

- growth and expenditure of the gross domestic product and their sectorial distribution,
- interest rates and cost of capital,
- unit of measure of inflation and indices,
- variations of employment and unemployment,
- migrations of population,
- health statistics and social policies,
- balance of payment and related data on international commerce,
- savings in households, intended spending, condition of funds,

[3] as stated by Abraham Lincoln in the Gettisburg Address -- elected by people in service of people.

- immediate foreign investments,
- births, deaths, life expectancy,
- agricultural production,
- data on the environment,
- taxes and tax policies,
- development of information society.

There are also other statistics that are departmentally oriented and hence horizontally not readily comparable. Their administrative content is a consequence of particular departmental regulations and does never consider a phenomenon in complete. It is crucial that decision makers faced with a abundance of data and contradictions, have to decide upon the future of a country and therefore about their political destiny. Correctness of decisions -- whether they will be liked or not by users of state services, i.e. voters -- is periodically decided upon at elections. There are very few political projects that extend over more than one mandate period, and there are very few voters -- or citizens, for that matter -- that are prepared to believe into necessity of being deprived themselves in order to so provide their offspring a better life. Resembling is the situation in various sectors and parts of the society that are because of their monopoly positions in situation to price their services uncommonly high as compared to the rest.

The new wave of globalization that was started by development of information technology, information highways, and better communication, has opened new problems of general and statistical comparability. The state of today is extremely dependent on global economical and social environment. Countries are looking after more safety and they create new alliances and partnerships (such as EU, North American Free Trade Association). International comparability of statistical data has become the prerequisite for subjects in power to begin cross border dialogue at all. For some countries ratings are extremely important for their present and future destiny. At the same time new financial tycoons (legal and natural persons alike) are more and more driving and global.

4. MODELING FOR STATE DECISIONS

Decisions that are made on the government or political level are normally in one way or another of importance to all the subjects in a country. Consequently, as much neutral and impartial source of data is needed to be sure that the information used in the decision making process was as much relevant as possible. Typical of those decisions is also that they require complex models that are hard to build, that estimates and information are often used rather than precise data, and that time span is normally rather long. All of these provide for that the solution of the decision function in terms of high probability of a provably correct solution is rather difficult. But let us suppose that there is a method as proposed in chapter 2. What a strength for any government it would be if it were able to produce provably correct decisions!

In political decision making, it is often that goals are vaguely defined (but not necessarily vaguely decided upon at the same time), that limitations are neglected, that the actual data is unimportant, and therefore a model is hardly possible to be spoken of. An example of a political decision *par excellence* would be the answer to the following question: is Slovenia at the time being already fit to join the European Union? Let us keep in mind that there are two aspects to be considered when answering the question: that of Slovenia and that of the European Union. Is it possible to predict the decisions of one and the other? All relevant data is known as Slovenia hides nothing in this respect. Time is the same for both -- now. But, as we know, decisions are different. So there must be a difference and, according to the process as defined in chapter 2, the difference must be in the models used. Otherwise the result ought to be the same, whether positive or negative, but the same. Another possibility is that goals of one or another are other than declared.

The above example has been used just to illustrate the issue. Internally, political decisions are normally much more evident in terms of models for two reasons: one is that it is so required by democratic parliamentary, legal, and other procedures where transparency is the common denominator. The other is that every government must deliver measurable results. Therefore, data is the same and equal for everybody, and models are hopefully agreed upon beforehand. However, as there is as yet no means to provide for provably correct decisions, there is always a danger of forcing models to fit decisions or vice versa.

5. THE STATE, DECISION MAKING, AND THE STATE STATISTICS

There is quite a lot of study of decision making at the government and departmental levels. Also known are various methods to build or provide platforms for decisions. Many of them are prepared by ministries, government departments, and are proposed by ministers. Important decisions-- in the domain of legislation, for example -- are also proposed by other branches of administration such as parliament, and ministries or cabinet must consider the decisions and take an attitude also to proposals of others. Data, and not only statistical, is often used as an argument to support a decision. Authors have a relatively long term experience in administration and must have of necessity read many law based decisions on projects. The conclusion they have come to is that normalization of data that is collected at present, and strategic decision about the information to be needed in the future (and by that requirements for statistical data) are of utmost importance.

To define information needs here are several methods known, but not discussed in detail further. They may be divided in two categories: inductive methods (interview, analysis of existing documents, mirror image), and deductive methods (information required for future decisions, goal oriented methods). As all of them have their strengths and weaknesses, it is convenient to combine the both categories. It is important to understand present and future decision processes. To support this objective, the Republic of Slovenia has successfully accomplished a project Data Model of the Republic of Slovenia. State Statistical Office has played an important role in the project and has also proposed new categories of data and new sources of collection thereof. As it has not executive power strong enough and cannot influence methods of work in ministries, the proposals were not always successful.

Whereas sources of data and information are quite formalized and available, less importance is normally given to the first element in the decision making matrix - the thinking. This is not to say that the decisions made have not been thought over many times and in many ways. It only means that the process is not as formalized in terms of an abstract model as it could be-- and indeed should be. There are many possible approaches to the building of models, which are all valid and legitimate. It is the challenge of optimizing the effort of model building that leads to the conclusion that a relatively easy method should be used. Rather lately, besides quantitative models, described in [2], and qualitative models, semi-quantitative models have been proposed. They seem to be very appropriate in describing continuous systems. Detailed description and some examples are given in [4] and [5].

5.1 Semi-quantitative modeling[4]

Systems can be studied in different ways: by observation, by experimenting with real-life and/or real-size situations, or by observation of models. In the case of state and statistical data it is practically impossible to experiment with real life situations. A real economic system cannot be studied by arbitrarily changing of needs, requirements, and by changes in providing an economy or a population with commodities and services. In such cases models are of utmost importance. A model is not merely a substitute of a system for purposes of study and it is also a valid functional simplification thereof. In this respect it is worth mentioning that different students will probably produce different models of a system inasmuch as they are interested in

[4] The method is described in detail in [5].

different aspects of the same system, but -- if the body of knowledge and the information at hand is the same -- if they are studying the same aspect, the model should be the same. As different aspects of study yield different models we may conclude that models are context-dependent.

Semi-quantitative modeling seems to be favourable to be used in case of complex situations as they offer models, testing of which is near to the way of human thinking. Normally, people tend to think in qualitative terms, and the beauty of semi-quantitative modeling is in that it offers a necessary impartiality which is needed if decisions are to be provably correct ones. The below diagram presents a semi-quantitative model of a queue before a motor way toll station.

Incoming vehicles is an independent variable, + and - in circles denote influence of variables on one another, and the vertical line in the variables denotes increasing or decreasing of a value of a variable. The more vehicles are coming in, the longer the queue, the more active the toll station will be and the more of the capacity of the toll station will be used. The above diagram is but a pale picture of a real situation as it is static. The computer program for semi-quantitative modeling however gives an incomparably more illustrative picture as it has also a dynamic component in that models may be animated and so tested -- relations may changed, if need be -- and proved. Consequently, we believe that the method is able to deliver provable correct decisions. The above example is not particularly related to state decision making; its value is in that the toll station queue can be dealt with also analytically. The results obtained by the semi quantitative model can be proved, and indeed are proved, by an analytical, i.e. quantitative model

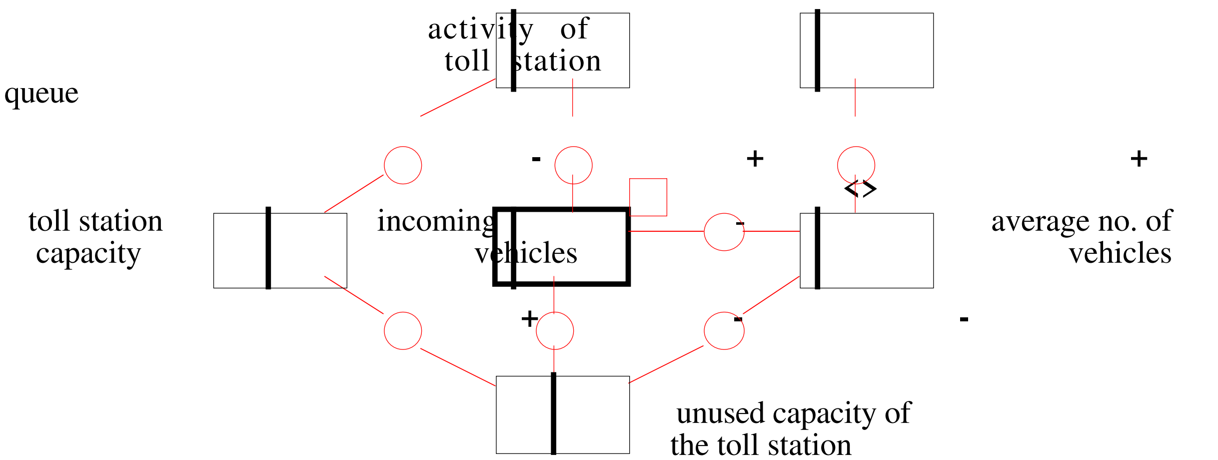

Diagram 4: Semi-quantitative model of a queue before a toll station[5]

It is obvious that state decisions deal with immeasurably more complex situations and therefore with incomparably more complex potential models. Nevertheless the method itself is such that makes possible building and testing of models where exact values of variables are not required, but solutions are still valid and applicable in real situations.

The advantage of semi-quantitative models is in that they utilize entities, relations and interactions among them rather than exact values of variables. They are rather simple to build and much more easy to test as compared to the quantitative ones. At the same time, they offer much more insight into the behaviour of the system that they describe as compared to qualitative models. For those reasons, authors believe that semi-quantitative models may be used successfully in cases where complex situations are to be evaluated and decided upon, and most of the government situations follow that paradigm. May we finally add that semi-quantitative

[5] The reproduction of the diagram was kindly allowed by Mr Radovan J Slanc.

modeling is a rather young area of study, and that also the concept provably correct decisions is, however promising, rather new. Nevertheless we believe that the two combined will prove extremely useful: statistical data deal with probabilities rather than exact values, and state decisions deal with relations among entities rather than variables. We also believe that there is a need to deliver provably correct decisions at the state level; the real issue is that of the political will to do so.

6. CONCLUSION

In the paper the authors tried to introduce a concept of a new class of decisions - that of *provably correct decisions*. For this purpose -- and not to even try to introduce novel concepts of systems and models -- it seemed to be appropriate to comment shortly on the two categories as well. Next is that they tried to propose a relatively new method of modeling, namely the *semi-quantitative* one. Statistical data has been discussed in the context of the state decisions rather than in the context of methods, sampling techniques, and mathematical tools that lay underneath. May it at this be noted point that statistical data may indeed be regarded as impartial for two important reasons. The first is that it does not serve any particular political party or any particular government, but rather it serves the state itself. As the state is immensely more stable than its infrastructures, political or other, the statistical data has to observe needs of the state. The next is that statistical methods have to be rather stable over time or else they would jeopardize carrying out longitudinal studies and probably also the comparability of data in wider, e.g. international context.

Related to statistical data as used for decisions at the state level may it be noted that there are so far no decision support systems that yield provably correct decisions. For now it is basically a question of attitude whether a decision produced by a decision support system is regarded as a correct one. The fact that a decision is a result of a formal procedure is by itself not enough to grant it a property of a proved correctness. It is to be hoped that a study of a new group of decision support systems will be initiated, possibly based on semi-quantitative modeling and this, combined with provably correct decisions, would without any doubt greatly improve decisions making processes and help the decision makers on all levels of decisions -- the higher the level, the more the help.

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TAKING CONTEXT INTO ACCOUNT WHEN TRANSFERING A KNOWLEDGE BASED APPLICATION FROM ONE ORGANIZATION TO ANOTHER. A CASE STUDY WITH FINSIM EXPERT

(extended abstract)

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Finsim represents a family of knowledge-based DSS applications used for financial analysis and planning in banks. The goal of the system has not changed since the first version described in Klein (1989)° FINSIM was designed to provide the user with:

- an in-depth analysis of the financial history of a company.
- a reporting system on the economic and financial performance of a company.
- a tool to simulate the consequences of the main financial decisions and of the evolution of the environment of the company

In our 1989 paper we pointed out that the main objective of the system was to enable the user to make the system evolves according to his needs. Since that time we have observed that these needs have evolved in the following directions:

- the need to take into account a wider range of sources of data which can be used with the system,
- the necessity of using a graphical interface to improve the ease of use and comfort,
- the need to improve further the capacity of the system to evolve by implementing a better independance between the interface and global logic of the system and its resources (models, reports, knowledge bases, etc.),
- the need to adapt the system more easily to various contexts,
- assistance of the financial diagnosis process using a knowledge based function.

Concerning the first point we use the term "family of models" because three standard versions of this model are in use in French companies and banks. Each version corresponds to the standard lay-out of balance sheets and income statements in the different tax categories used for reporting to the French fiscal authorities. Each of these standard lay-outs is defined by a list of accounting variables. The existence of this standard lay-out also makes it possible to develop applications using data readily available in French companies. Industry specific versions of this DSS application have also been developed and are currently in use for road transport companies Klein (1987) and for large farms.

Concerning the second point the new version of FINSIM, described for the first time in this paper, has now a graphical user interface. This version of FINSIM was first used in 1995. This version is developed using the object version of OPTRANS. The use of this object version implies several fundamental consequences for the application:

- the interface is separated from the models,
- the modeling formalism has been improved in clarity and power,
- the capacity to evolve has been extended.

Since the introduction of this new version the system as been transfered to new organiations and a strategy has been defined to adapt it more easily to new contexts.

In the paper,we first give a general presentation of FINSIM with the nature of the data that are used, the report edition, the way in which graphics are defined and stored, the formulation fo a scenario, and financing. Section 3 introduces the problem of transfering FINSIM from one organization to another. Section 4 describes the development of the environment that is used, and Section 5 the architecture of FINSIM. Section 6 presents the way in which context is taken into account.