organizacija

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- *new and innovative organizational structures and approaches;*
- *managerial aspects of quality management;*
- *organizational behavior;*
- *human resources management;*
- *development, restructuring and management of information systems;*
- *interorganizational systems, electronic commerce;*
- *decision making, decision support.*

In particular, we seek papers which cover state-of-art developments in organizational theory and practice, and present new insights that improve our understanding in the subject area of the journal

Organizacija je interdisciplinarna znanstvena revija, ki objavlja prispevke s področja organizacije, informatike in kadrovskega managementa. Primeri tematskih sklopov, ki jih pokriva revija, so:

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- *novi organizacijski pristopi ter njihova uporaba*
- *organizacijski ukrepi za doseganje večje produktivnosti, ekonomičnosti in rentabilnosti poslovanja in proizvodnje*
- *management kakovosti*
- *kadrovanje in izobraževanje kadrov pri prestrukturiranju podjetij*
- *stimulativnost nagrajevanja v spremenjenih lastninskih razmerah*
- *prestrukturiranje organizacijskih in informacijskih sistemov*
- *načrtovanje, razvoj in uporaba informacijske tehnologije in informacijskih sistemov*
- *medorganizacijski sistemi, elektronsko poslovanje*
- *odločanje, podpora odločanju, direktorski informacijski sistemi*

Vsebina ni omejena na navedene tematske sklope. Še posebej želimo objavljati prispevke, ki obravnavajo nove in aktualne teme in dosežke razvoja na predmetnem področju revije, ter njihovo uvajanje in uporabo v organizacijski praksi.

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Editorial

The aim of this special issue "Recent Advances in Systems, Decision Making, Education and other Complex Problems" is to continue presenting the research achievement from the area of Systems Approach and Decision Support Systems for assessments of complex problems. The majority of the contributions were presented at The 23rd European Conference on Operational Research, EURO XXIII 2009, held in Bonn, Germany, in the stream Simulation Based Decision support, chaired by Miroljub Kljajić and in the stream "Migration, Education and Sustainable Development", chaired by Hanife Akar. The special issue includes papers dealing with the development of simulation methodology, modeling tools and practice for decision assessment, service systems, control and optimization and social dynamics research. The last two decades much stressed on neoliberal education policies as a way to cope with globalization and its impact on nation states. The current trend leads to a paradigm shift that considers a more collectivist trends that includes social and environmental issues in its agenda to a more sustainable living that includes issues of environmental pedagogy and social justice. Current curricula policies emphasize issues of global warming, climate change, protection of species and the ecology as a way to foster a sustainable development, and foci is on social issues such as poverty, health, migration, and cultural diversity, and a need for developing life-long learning skills. To address those issues above firm policies need to be established as a result of our continues search for a sustainable future. In that respect, the paper entitled "A system dynamics model for improving primary education enrollment in a developing country" deals with system dynamics approach for studying the importance of infrastructure facilities on the quality of primary education system in a developing nation. By examining infrastructure facilities of school, equity policies can be generated to gain access to qualified education in an equitable environment. The model is built using the Cross Impact Analysis (CIA) method of relating entities and attributes relevant to the primary education system in any given community. The CIA model enables us to predict the effects of infrastructural facilities on the community's access of primary education. This may support policy makers to take more effective actions in campaigns that attempt to improve literacy. This is a powerful methodology and computer simulation modeling technique for framing, analyzing, and discussing complex issues and problems.

The paper, entitled "A methodology for improving strategic decisions in social systems with a lack of information", addresses the use of system dynamic methodology for the strategy development of the city of Santa Cruz (on the Canary Islands). It has two main sections: the elaboration of a qualitative model and the use of System Dynamics. Through combining them in a way that allows mixing qualitative and quantitative information it helps the reader to achieve a better understanding of the structure of the region, to know the tendencies of the present scenario and to estimate of the effects of alternative strategic decisions. Despite the authors have obtained results working with scarce quantitative information, the methodology they utilized may have good incentives to be applied to other social systems with similar characteristics.

The paper entitled "Development of a web application for dynamic production scheduling in small and medium enterprises" describes the development of a web-based dynamic job-shop scheduling system for small and medium enterprises. In large enterprises, scheduling is mainly performed with appropriate technology by human experts; many small and medium enterprises lack the resources to implement such a task. The main objective was to develop a cost-effective, efficient solution for job-shop scheduling in small and medium enterprises with an emphasis on accessibility, platform independence and ease of use. The solution is built upon modular programming principles and enables dynamic scheduling on the basis of genetic algorithms. The solution has been developed to covers the five main functionalities that completely support the scheduling process, i.e., making an inventory of resources available in the company, using it in the process of production planning, collecting data on production activities, distribution of up-to-date information and insight over events in the system.

The paper entitled "The COMPRAM methodology and complex societal problems – an analysis of the case of children born of war" analyses the applicability of the Compram methodology to the group of children born of war. Children born of war are children born during and after wars and conflicts where the father is or has been a member of an enemy, allied or peacekeeping force and the mother a local citizen. The Compram methodology is a method for handling complex societal problems in a transparent and structured way. It is a multi disciplined, multi level, multi actor methodology based on the theory of societal complexity. The Compram methodology can be applied to a variety of complex societal problems; natural problems such as flu pandemic, earth quakes and floods as well as man-made problems like terrorism, healthcare problems and agricultural problems.

The last paper of this issue, "Simulated decision learning in a multiactor setting", presents the development of the decision analysis – and subsequent learning from the outcomes from the simulation model for disaster situations. Here, this approach to a continuous improvement of decision outcomes is put one step further within the area of crisis and disaster management. This is done by introducing multiactors making simultaneous decisions with just partial information about each other. Further, decision outcomes are achieved from a simulation model rather than from the real object system.

We guest editors hope that our selected topics display the state-of-the-art of the research efforts over the world coping with complex problem solving in a holistic way which is characteristic for modern Operations Research! Moreover, we are very thankful to our journal Organizacija (Organization - Journal of Management, Information Systems and Human Resources) for having given us the opportunity and honour of hosting this special issue as a scientific project and service to the people on earth. We express our gratitude to the Editors of Organizacija, and hope that our special issue will well-demonstrate Organizacija being a premium journal and of a great scientific and social value!

The Guest Editors:

Miroljub Kljajić,
Gerhard-Wilhelm Weber
and Hanife Akar.

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A System Dynamics Model for Improving Primary Education Enrollment in a Developing Country

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The system dynamics approach is a holistic way of solving problems in real-time scenarios. This is a powerful methodology and computer simulation modeling technique for framing, analyzing, and discussing complex issues and problems. System dynamics modeling is often the background of a systemic thinking approach and has become a management and organizational development paradigm. This paper proposes a system dynamics approach for studying the importance of infrastructure facilities on the quality of primary education system in a developing nation. The model is built using the Cross Impact Analysis (CIA) method of relating entities and attributes relevant to the primary education system in any given community. The CIA model enables us to predict the effects of infrastructural facilities on the community's access of primary education. This may support policy makers to take more effective actions in campaigns that attempt to improve literacy.

Keywords: developing countries, system modeling, cross impact analysis, simulation, system dynamics, primary education

1 Introduction

The first stage of compulsory education is primary or elementary education. In most countries, it is compulsory for children to receive primary education, though in many jurisdictions it is permissible for parents to provide it. The transition to secondary school or high school is somewhat arbitrary, but it generally occurs at about eleven or twelve years of age. Some educational systems have separate middle schools with the transition to the final stage of education taking place at around the age of fourteen.

The major goals of primary education are achieving basic literacy and numeracy amongst all pupils, as well as establishing foundations in science, geography, history and other social sciences. The relative priority of various areas, and the methods used to teach them, are areas of considerable political debate. Some of the expected benefits from primary education are the reduction of infant mortality rate, population growth rate, crude birth and death rate, and so on.

Because of the importance of primary education, there are several models proposed to study the factors influencing the primary school enrollment and progression. These are logistic regression models (Admassu 2008), poisson regression models (Admassu 2008), system models (Altamirano and van Daalen 2004, Karadeli et al. 2001, Pedamallu 2001, Terlou et al. 1991), behavioral models (Benson 1995, Hanushek et al. 2008) constructed for the context of different countries. Several factors which influence the school enrollment and drop outs are identified in various studies. Some of the vital factors at the macro level are social, economic and logistics factors (Benson 1995), and at the micro level there are parental education, household wealth/income, distance to school, financial assistance to students and quality of school (Admassu 2008, Benson 1995, Rena 2007). An early system dynamics model to investigate the low efficiency of primary education

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in Latin America is introduced by Terlou et al. (1991). This model investigates the progression through primary school and includes causal chains leading to progression, dropout and repetition of students. Karadeli et al. (2001) develop a model to analyze the future quality of the Turkish educational system based on the budget of the Ministry of National Education. In this model, quality of education and progression of students is influenced by the student to teacher ratio and student to class ratio. Altmirano and van Daalen (2004) propose a system dynamics model to analyze the educational system of Nicaragua and helps in identifying and analyzing the consequences of policies that are aimed at improving the coverage of the different educational programs, reducing illiteracy and increasing the average number of schooling years of the population. This study shows that implementing literacy programs and introducing a program in which families in extreme poverty receive a subsidy has an effect on school coverage as well as on the number of illiterate people. More recently, Hanushek et al. (2008) shows that school quality and grade completion by students are directly linked. The World Bank has published several reports on achieving universal primary education (Bruns et al. 2003, Serge 2009). In particular, Serge (2009) focuses on the infrastructure challenge in Sub-Saharan Africa and the constraints to scale up at an affordable cost.

The model proposed in this study aims at identifying the importance of infrastructural facilities on school enrollment and progression beside factors such as quality of teaching and income level. This point is also investigated by Akar (2008) who reports about the infrastructural problems at Turkish schools and their negative impact on students. Here, we present the details about the model constructed for this purpose, the selection of attributes and entities and the simulation results that identify the variables that impact the quality of primary education. The simulation is conducted by using the Gujarat primary education data in India (Pedamallu 2001).

2 The model

The model proposed here is developed by using the cross impact analysis method (CIA). The CIA method is one of the most popular systems thinking approach developed for identifying the relationships among the variables defining the systems (Gordon and Hayward 1968, Kane 2002, Weimer-Jehle 2006). This method first was developed by Theodore Gordon and Olaf Helmer in 1966 in an attempt to answer a question whether perceptions of how future events may interact with each other can be used in forecasting. As it is well known, most events and trends are interdependent in some ways. The CIA method provides an analytical approach to the probabilities of an element in a forecast set, and it helps to assess probabilities in view of judgments about potential interactions between those elements. (We refer to Lane (1999) and Mohapatra et al. (1994) for more detailed information on system dynamics modeling.) CIA has been used to model and simulate several real-time problems (for example: Pedamallu et al. 2009, Hayashi et al. 2006). Here, we briefly describe the steps of the CIA method through a block diagram given in Figure 1.

2.1 Definition of the system

Systems defined based on entities, which interact with each other and produce some outputs that are either designed or natural. A system receives inputs and converts them through a process and produces outputs. All the outputs of a system need not be desirable. In the present context, the system represents the primary education system.

a. Environment
Every system functions in an Environment, which provides inputs to the system and receives outputs from the system. In our context, the Environment is the society.

b. Structure
All systems have a Structure. The 'body' of a system's structure is represented by the entities of the system and their interrelationships or linkages or connections. The entities in our system are defined as follows.
1. student,
2. teacher,
3. parents,
4. educational officials,
5. infrastructure and
6. local community.

c. Linkages
The linkages among entities may be physical (e.g., facilitates), electro-magnetic (e.g., electrical, electronic and communications systems, and so on), and information-based (e.g., influence, and so on). It is important to try and understand, what linkages exist in the system's structure, which entities are linked with each other, and the implications of these linkages on the behavior of the entities in particular. The entity relationship diagram of the system is illustrated in Figure 2. Exchange of matter, information and/or spirit between two entities causes a change in the state of both entities. This is reflected as system behavior.

2.2 System entities and relationships equations

The dynamic change of the system state is referred to as system behavior. The state of a system is an instantaneous snapshot of levels (or, amounts) of the relevant attributes (or, characteristics) possessed by the entities that constitute the system. In all systems, every entity possesses many attributes, but only a few attributes are 'relevant' with respect to the problem at hand. Some attributes are of immediate or short-term relevance while others may be of relevance in the long run. The choice of relevant attributes has to be made carefully, keeping in mind both the short-term and long-term consequences of solutions (decisions). All attributes can be associated with given levels that may indicate quantitative or qualitative possession. The set of attributes identified for the model are given below.

Entity 1: *Student:*
1.1 Level of Enrollment (loe).
1.2 Level of boys dropouts in a school (lbd).
1.3 Level of girls dropouts in a school (lgd).
1.4 Level of repeaters in a school (lr).

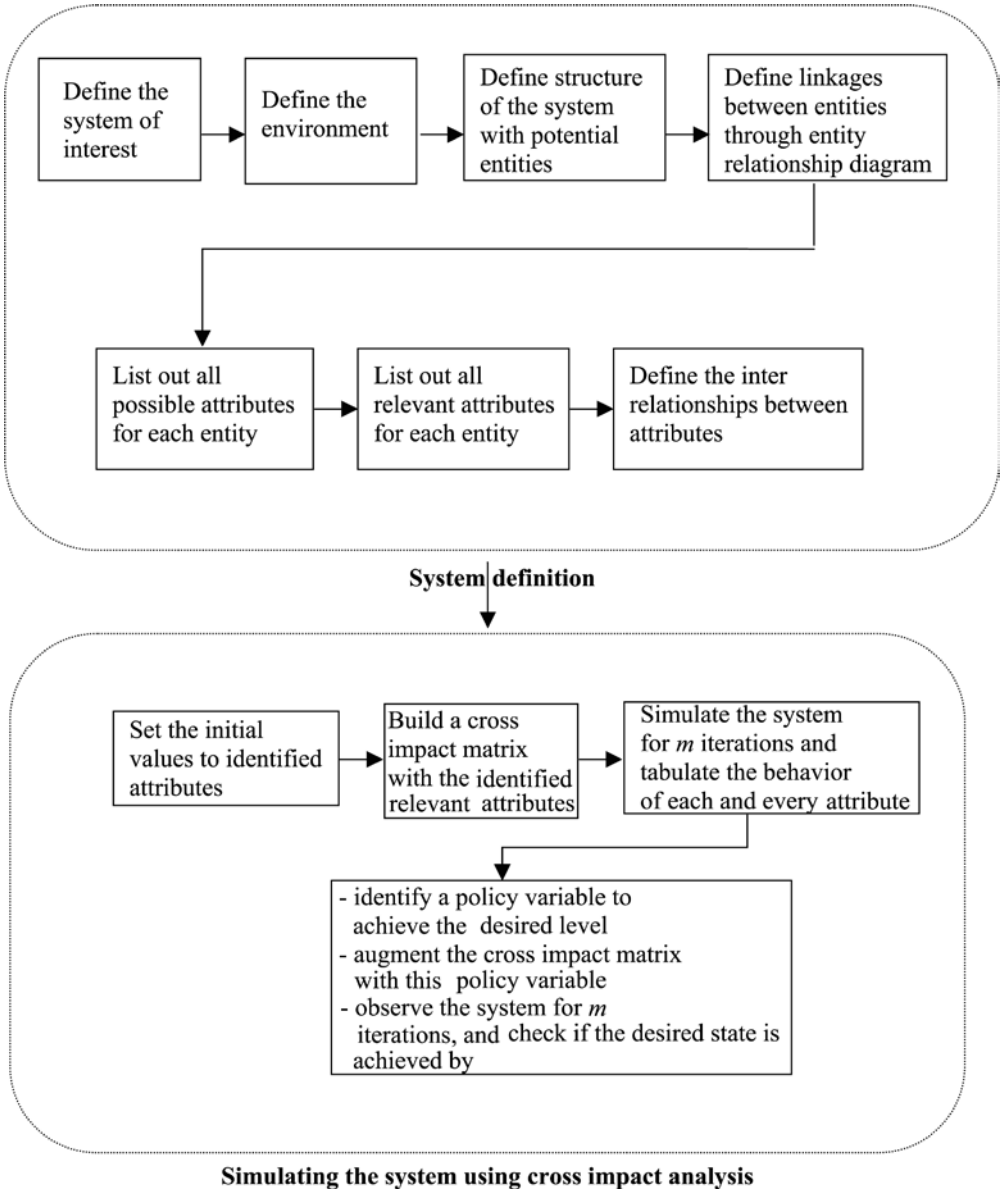

Figure 1: Block diagram for the steps of the CIA method.

Entity 2: *Teacher:*
2.1 Level of perceived quality of teaching by the Students (lts).
2.2 Level of perceived quality of teaching by the Parents (ltp).

Entity 3: *Parents:*
3.1 Educational level of parents (elp).
3.2 Income level of parents (ilp).
3.3 Level of expectations from school by the parents (leps).
Entity 4: *Educational officials:*
4.1 Level of perceived quality of teaching by the District educational officer (DEO) (ltd).

Entity 5: *Infrastructure:*
5.1 Level of Space and ventilation available in a Classroom (lsv).
5.2 Level of cleanliness and other facilities such as board, mats, table/chair, educational aids (maps, toys, charts, etc.) (lc).
5.3 Level of sanitation facilities for general purpose (for both boys and girls) (ls_g).
5.4 Level of separate sanitation facilities for girls (ls_s).
5.5 Level of drinking water facility available (ldw).
5.6 Level of availability of Playground area and other equipment for children used in playing (lpa).
5.7 Level of bad organisation in the classrooms (lbo):
Number of cases in which more than one class is conducted in a single instructional classroom.
Number of cases in which more than 40 people are accommodating in a single instructional classroom.

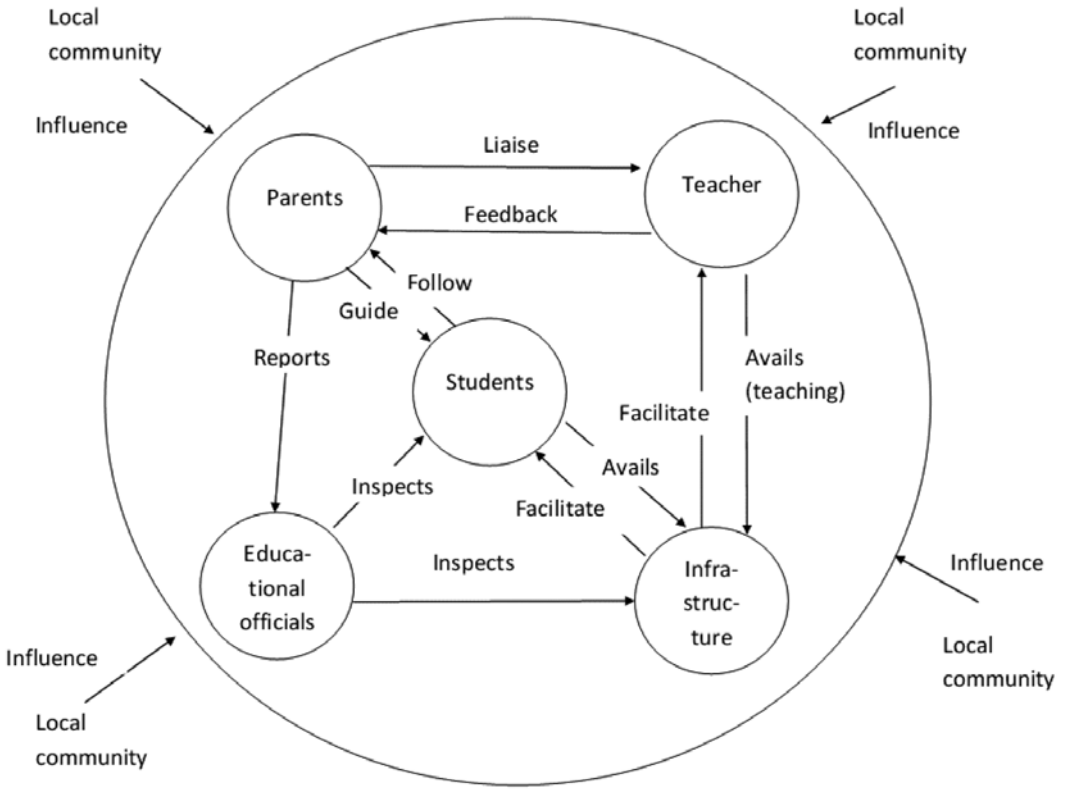

Figure 2: Entity relationship diagram for the primary education system.

Entity 6: *Local community:*
6.1 Level of participation of local community (llc).
6.2 Level of awareness of local community about educational benefits (lale).

When entities interact through their attributes, the levels of the attributes might change, i.e., the system behaves in certain directions. Some changes in attribute levels may be desirable while others may not be so. Each attribute influences several others, thus creating a web of complex interactions which eventually determine system behavior. In other terms, attributes are variables that vary from time to time. They can vary in the system in an unsupervised way. However, variables can be controlled directly or indirectly, and partially by introducing new intervention policies. The interrelationships among variables should be analyzed carefully before introducing new policies.

The following conjectures are valid in the systems approach (the following subsection is borrowed from Kane (2002) paper).

a. Modeling and forecasting the behavior of complex systems are necessary if we are to exert some degree of control over them.
b. Properties of variables and interactions in large scale system variables are bounded such that:
i. System variables are bounded. It is now widely recognized that any variable of human significance cannot increase indefinitely. There must be distinct limits. In an appropriate set of units these can always be set to a value between one and zero:
ii. A variable increases or decreases according to whether the net impact of the other variables is positive or negative.
iii. A variables' response to a given impact decreases to zero as that variable approaches its upper or lower bound. It is generally found that bounded growth and decay processes exhibit this sigmoidal character.
iv. All other things being kept fixed (constant), a variable (attribute) will produce a greater impact on the system as it grows larger (ceteris paribus).
v. Complex interactions are described by a looped network of binary interactions (this is the basis of the cross impact analysis).

With these conditions in mind consider the following mathematical structure. Since state variables are bounded above and below, they can be rescaled to the range zero to one. This for each variable we have

$$0 < x_i(t) < 1, \text{ for all i = 1, 2, …, N and all t} \geq 0 \qquad (1)$$

Where xi (t) is the level of variable i in period t.

To preserve boundedness, $x_i(t + \Delta t)$ is calculated by the transformation

$$x_i(t+\Delta t) = x_i(t)^{P_i} \quad (2)$$

where the exponent $P_i(t)$ is given by

$$P_i(t) = \frac{1+\frac{\Delta t}{2}\sum_{j=1}^{N}(|\alpha_{ij}|-\alpha_{ij})x_j}{1+\frac{\Delta t}{2}\sum_{j=1}^{N}(|\alpha_{ij}|+\alpha_{ij})x_j}. \quad (3)$$

where a_{ij} are matrix elements giving the impact of variable x_j on x_i and Δt is the time period of one iteration of the system's simulation.

Equation (3) guarantees that $P_i(t) > 0$ for all i = 1, 2, …, N and all t > 0. Thus the transformation (2) maps the open interval (0, 1) onto itself, preserving boundedness of the state variables (condition 1 above). Equation (3) can be made somewhat clearer if we write it in the following form:

$$P_i(t) = \frac{1+\Delta t\,|\,\text{sum of negative impacts on } x_i\,|}{1+\Delta t\,|\,\text{sum of positive impacts on } x_i\,|}. \quad (4)$$

When the negative impacts are greater than the positive ones, $P_i > 1$ and x decreases, while if the negative impacts are less than the positive ones, $P_i < 1$and x decreases. Finally when the negative and positive impacts are equal, $P_i = 1$ and x remains constant.

3 Simulating the system using cross impact analysis

There are four steps to follow while implementing the cross impact analysis in our case. First, we conduct the simulation by considering the primary education system without human intervention. Then, we run the same analysis after implementing some selected policy variables such as infrastructure improvement and observe the change in system dynamics.

We now describe how we construct the model in the following four steps.

Step 1. Set the initial values for attributes. The initial values are obtained from published sources and surveys conducted. Here, we use the survey data reported in Pedamallu (2001). Table 1 illustrates the initial values for various attributes identified in this study.

Step 2. Build a cross impact matrix with the identified relevant attributes. Summing the effects of column attributes on rows shows the effect of each attribute in the matrix. The parameters a_{ij} can be determined by creating a pairwise correlation matrix after collecting the data, and these can be adjusted by subjective assessment. In Table 2, qualitative impacts are quantified subjectively. The impact of infrastructural facilities on primary school enrollments and progression become visible by running the simulation model. A cross-impact matrix for the attributes listed above is illustrated in Table 3.

Step 3. Simulate the system for a number of 50 iterations (m iterations) and tabulate the behavior of each and every attribute in each every iteration. Plot the results on a worksheet.

Table 1: Initial values for attributes

Attribute	Initial value
Level of Enrollment (*loe*)	0.71
Level of Space and ventilation available in a Classroom (*lsv*)	0.5
Level of cleanliness and other facilities such as board, mats, table/chair, educational aids (maps, toys, charts, etc.) (*lc*)	0.5
Educational level of parents (*elp*)	0.35
Income level of parents (*ilp*)	0.35
Level of expectations from school by the parents (*leps*)	0.6
Level of perceived quality of teaching by the Students (*lts*)	0.45
Level of perceived quality of teaching by the Parents (*ltp*)	0.35
Level of perceived quality of teaching by the District educational officer (DEO) (*ltd*)	0.35
Level of sanitation facilities for general purpose (for both boys and girls) (*ls_g*)	0.39
Level of separate sanitation facilities for girls (*ls_s*)	0.28
Level of availability of Playground area and other equipment for children used in playing (*lpa*)	0.3
Level of participation of local community (*llc*)	0.25
Level of awareness of local community about educational benefits (*lale*)	0.25
Level of repeaters in a school (*lr*)	0.05
Level of boys dropouts in a school (*lbd*)	0.2
Level of girls dropouts in a school (*lgd*)	0.29
Level of bad organisation in the classrooms (*lbo*)	0.69
Level of drinking water facility available (*ldw*)	0.34

We apply Step 3 and illustrate, in Figure 3, the simulation of the system for 50 iterations without any policy related variables. It is observed that there is sharp increase in enrollment rate at the beginning phase of the simulation (i.e., for the first 12 iterations). However, there is a steady decrease in the enrollment rate after a certain period of time. The trend is observed in the number of dropouts and repeaters. In order to observe the effect of infrastructure attributes, we include them as policy variables in our next step. The policy variable that is selected involves additional investment in the infrastructure related attributes and elements which we call it as "policy variable".

Table 2: Impact rates of variables (attributes).

Representation of Impact	Value	Description
++++	0.8	Very strong positive effect
+++	0.6	Strong positive effect
++	0.4	Moderate positive effect
+	0.2	Mild positive effect
0	0	Neutral
_	-0.2	Mild negative effect
_ _	-0.4	Moderate negative effect
_ _ _	-0.6	Strong negative effect
_ _ _ _	-0.8	Very strong negative effect

Step 4. Identify a policy variable to achieve the desired level or state and augment the cross impact matrix with this policy variable with the qualitative assessment of pairwise attribute interactions. Re-simulate the model.

In this re-simulation run, we select an improvement in infrastructural facilities as the policy variable. In Table 4, we include the relationship of the policy variable to other attributes. We observe the system for 50 iterations, and check if the desired state is achieved by introducing the policy variable. We then compare the results obtained in the two simulation runs. The detailed rates of change in all variables during the two simulation runs taken before and after adding the policy variable are indicated in the Appendix.

Figure 4 illustrates the results of the simulated system after adding the identified policy variable in Step 4. Here, it is observed that the policy variable is effective on improving the enrollment and dropout and repeater rates.

Figure 5 illustrates the changes in important variables in detail such as the enrollment rate, level of boy dropouts, level of girl dropouts, level of repeaters, level of sanitation facilities for general purpose, level of separate sanitation facilities for girls, level of bad class organization, and level of space and ventilation available in a classroom. The initial values for these attributes are listed as 0.71, 0.2, 0.29 and 0.05 for enrollment of students, level of boy dropouts, level of girl dropouts, level of repeaters, respectively. After a simulation of 50 iterations without any policy variables, we observe that there is a rise in the enrollment level in the first 12 iterations and then, enrollment starts to decline. A similar kind of trend is observed in the level of boy dropouts in the first four iterations and in the level of girl dropouts in the first five iterations. This early amelioration in the dropout rates is short lived, and both boy and girl dropouts increase steadily thereafter. We validate the simulation results by comparing them with observed levels of enrollment, dropouts and repeaters published by Directorate of Primary Education, Gandhinagar (http://gujarat-education.gov.in/primary/mahiti/ankadakiyan_mahiti/index-eng.htm).

After a policy variable related to infrastructure improvements is introduced, a positive impact is observed on the level of space and ventilation available in classrooms, level of cleanliness and other facilities such as board, mats, table/chair, educational aids (maps, toys, charts, etc.), level of separate sanitation facilities for girls, level of general sanitation facilities, level of available drinking water facilities, and class organization. These impacts are discussed with education officials, parents, students, and other local community people. By introducing this policy variable, the enrollment rate has

Table 3: Cross impact matrix for primary education system.

	loe	lsv	lc	elp	ilp	leps	lts	ltp	ltd	ls_g	ls_s	lpa	llc	lale	lr	lbd	lgd	lbo	ldw
loe	0	+++	+++	+++	+++	+++	++	++	0	+++	+++	+++	0	0	0			----	+++
lsv	---	0	0	0	0	0	0	0	+++	0	0	0	+	+	0	0	0	-	0
lc	---	0	0	0	0	0	0	0	+++	0	0	0	+	+	0	0	0	-	0
elp	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
ilp	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
leps	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
lts	0	++	++	0	0	0	0	0	+	0	0	+	0	0	0	0	0	---	0
ltp	0	0	0	0	0	0	0	0	+	0	0	+	0	0	0	0	0	---	0
ltd	0	0	0	0	0	0	+	+	0	0	0	0	0	0	0	0	0	---	0
ls_g	---	0	0	0	0	0	0	0	+++	0	0	0	0	+	0	0	0	0	0
ls_s	---	0	0	0	0	0	0	0	+++	0	0	0	+	+	0	0	0	0	0
lpa	---	0	0	0	0	0	0	0	0	0	0	0	+	+	0	0	0	0	0
llc	0	0	0	0	0	0	0	0	0	0	0	0	+	+	0	0	0	0	0
lale	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
lr	+	0	0	0	0	0	---	---	0	0	0	0	+	0	0	0	0	+++	0
lbd	0	---	---	---	---	---	-	-	0	---	0	---	0	-	++++	0	0	++++	-
lgd	0	---	---	---	---	---	-	-	0	---	---	---	0	-	++++	0	0	++++	-
lbo	++++	0	0	0	0	0	0	0	---	0	0	0	0	0	0	0	0	0	0
ldw	---	0	0	0	0	0	0	0	0	0	0	0	+	+	0	0	0	0	0

improved steadily from an initial value of 0.71 to unity in a few iterations. Further, the level of repeaters increased to a value of 0.12 from an initial value of 0.05 in first 14 iterations, and then declined thereafter. This is logical in the sense that an improvement in the infrastructure doesn't have an instant impact on the level repeaters, but it would have an instant impact on the enrollment rate because students and parents are more eager to have the children attend a nice looking healthy school. The level of bad organization in the classroom is not greatly affected by the improvement in infrastructure facilities because there are several other attributes that influence this variable such as the level of perceived quality of teaching by the district educational officer and the number of teachers available for teaching. Consequently, the level of bad classroom organization is reduced from 0.69 to 0.57 in the second simulation run. In previous studies found in the literature, it is observed that the quality and the number of teachers have significant impacts on the enrollment, dropouts and repeaters. The design of our proposed model is sufficiently flexible to accommodate those impacts in future studies.

To summarize, in this study, we find that infrastructural facilities have significant impacts on the enrollment, dropout and repeater rates. This study is not meant to exclude any other important variables such as gender and parental status that affect school attendance and dropouts. Other simulations can be designed using the CIA to include parental and gender related policy variables to analyze their effects on enrollment.

5 Conclusion

A cross-impact model is developed here to study the influence of infrastructure facilities on primary education enrollment and progression. The cross-impact matrix illustrates the influence of one variable over the others and it also has a provision to identify the impact variables (i.e., policy variables). Here, we construct a model based on primary education data obtained in a survey conducted in Gujarat, India. Simulation results show that infrastructure improvement would indeed increase the enrollment rate in primary education.

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Table 4: Cross impact matrix for primary education system after adding policy variable.

	loe	ltv	lc	elp	ilp	leps	lts	ltp	ltd	ls_g	ls_s	lpa	llc	lale	lr	lbd	lgd	lbo	ldw	policy
loe	0	+++	+++	+++	+++	+++	++	++	0	+++	+++	+++	0	0	0			----	+++	0
ltv	---	0	0	0	0	0	0	0	+++	0	0	0	+	+	0	0	0	-	0	++++
lc	---	0	0	0	0	0	0	0	+++	0	0	0	+	+	0	0	0	-	0	++++
elp	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
ilp	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
leps	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
lts	0	++	++	0	0	0	0	0	+	0	0	+	0	0	0	0	0	---	0	0
ltp	0	0	0	0	0	0	0	0	+	0	0	+	0	0	0	0	0	---	0	0
ltd	0	0	0	0	0	0	+	+	0	0	0	0	0	0	0	0	0	---	0	0
ls_g	---	0	0	0	0	0	0	0	+++	0	0	0	0	+	0	0	0	0	0	+++
ls_s	---	0	0	0	0	0	0	0	+++	0	0	0	+	+	0	0	0	0	0	+++
lpa	---	0	0	0	0	0	0	0	0	0	0	0	+	+	0	0	0	0	0	+++
llc	0	0	0	0	0	0	0	0	0	0	0	0	+	+	0	0	0	0	0	0
lale	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
lr	+	0	0	0	0	0	---	---	0	0	0	0	+	0	0	0	0	+++	0	0
lbd	0	---	---	---	---	---	-	-	0	---	0	---	0	-	++++	0	0	++++	-	0
lgd	0	---	---	---	---	---	-	-	0	---	---	---	0	-	++++	0	0	++++	-	0
lbo	++++	0	0	0	0	0	0	0	---	0	0	0	0	0	0	0	0	0	0	----
ldw	---	0	0	0	0	0	0	0	0	0	0	0	+	+	0	0	0	0	0	+++

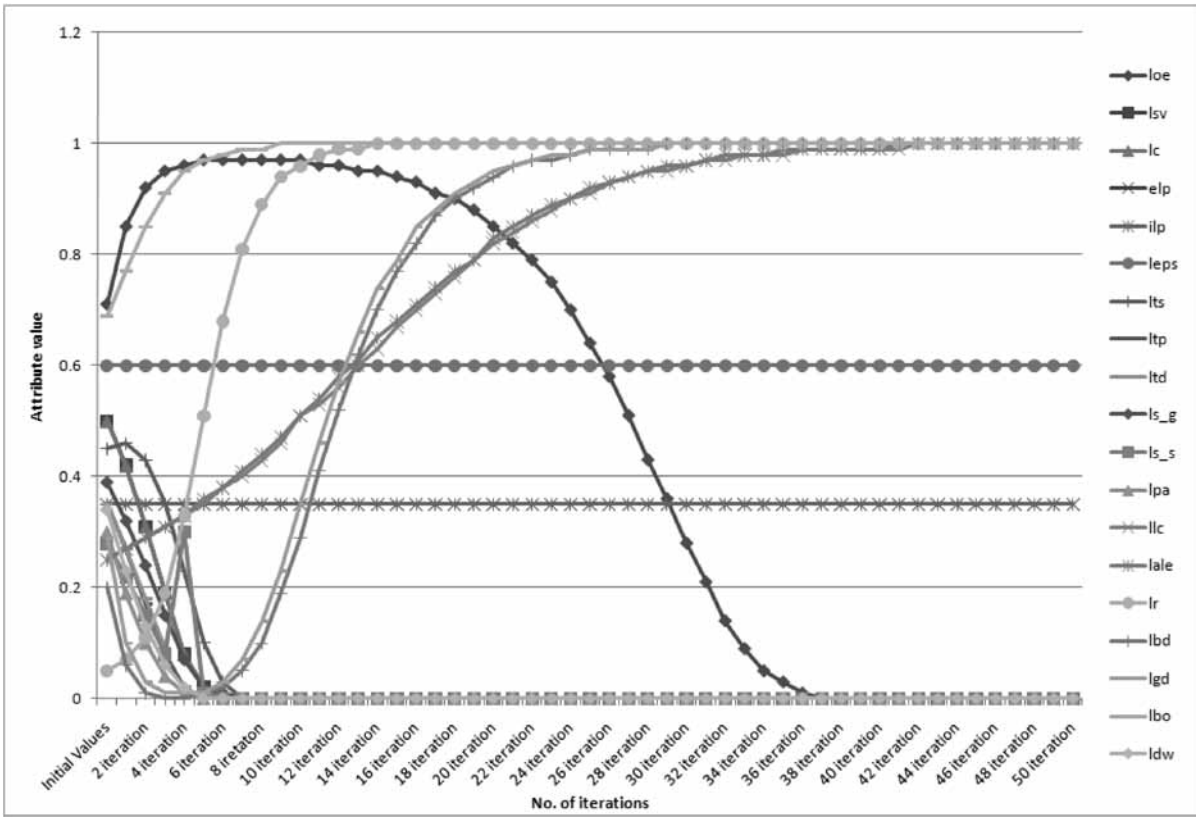

Figure 3: Behavior of primary educational system before adding the policy variable.

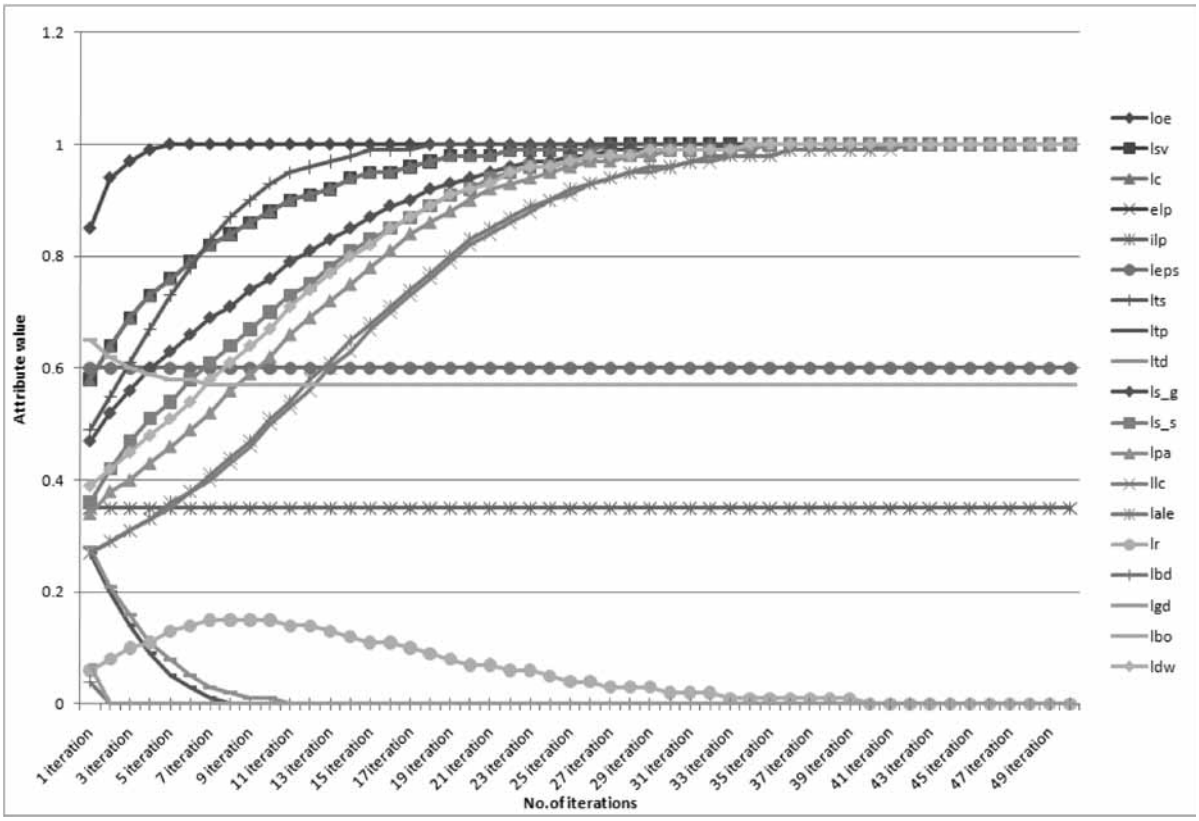

Figure 4: Behavior of primary educational system after adding the policy variable.

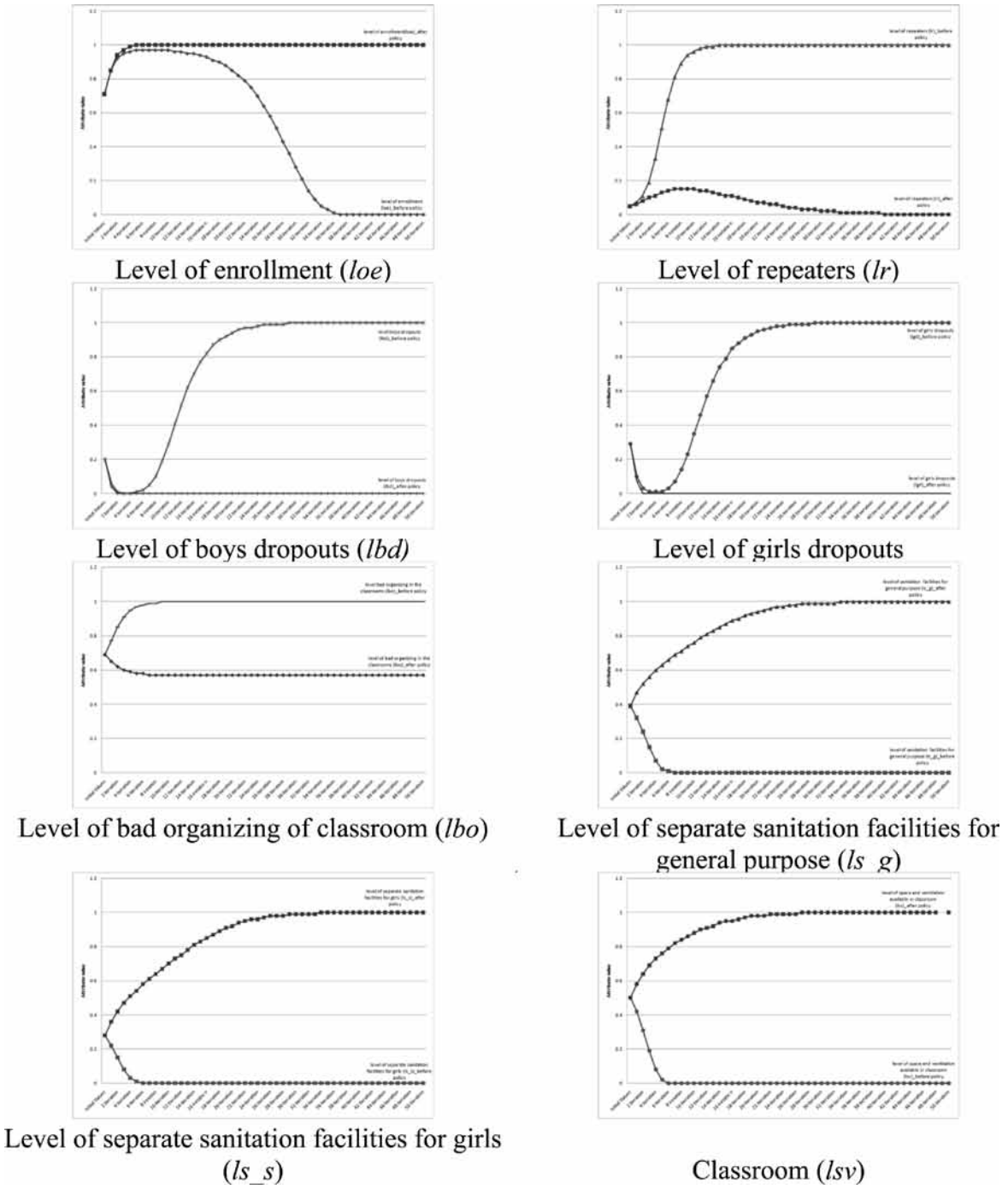

Figure 5: Important variable changes from before and after policy variable implementation. Color legend (in the electronic version of the paper): Blue line: after introducing policy variable; Red line: before introducing policy variable)

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Model izboljšanja vpisa v osnovnošolsko izobraževanje v državi v razvoju po metodi sistemske dinamike

Modeli sistemske dinamike so celovita metoda reševanja kompleksnih problemov s pomočjo scenarijev. Omogočajo, da skupaj z metodo računalniške simulacije analiziramo kompleksne probleme. Modeliranje z metodo sistemske dinamike je pogosto osnova za sistemsko razmišljanje in predstavlja managersko in organizacijsko razvojno paradigmo. V članku je opisan pristop na osnovi sistemske dinamike pri raziskavi pomembnosti infrastrukturnih zmogljivosti na kakovost osnovnega izobraževanja v državi v razvoju. Model je izdelan s pomočjo navzkrižne analize vpliva (Cross Impact Analysis - CIA), metode, ki primerja entitete in atribute značilne za osnovno izobraževanje v neki dani skupnosti. Model CIA omogoča, da predvidimo vpliv infrastrukturnih zmogljivosti na dostopnost te skupnosti do osnovnega izobraževanja. To lahko pomaga javnim odločevalcem, da bolj učinkovito planirajo akcije, ki poskušajo izboljšati pismenost.

Ključne besede: države v razvoju, modeliranje sistemov, navzkrižna analiza vpliva, simulacija, sistemska dinamika, osnovno izobraževanje

Appendix

1. Simulation results for attributes before adding the policy variable (attribute values are rounded off to two digits)

Attributes	Initial Values	1 iteration	2 iteration	3 iteration	4 iteration	5 iteration	6 iteration	7 iteration	8 iretaton	9 iteration	10 iteration	11 iteration	12 iteration	13 iteration	14 iteration
loe	0.71	0.85	0.92	0.95	0.96	0.97	0.97	0.97	0.97	0.97	0.97	0.96	0.96	0.95	0.95
lsv	0.5	0.42	0.31	0.19	0.08	0.02	0	0	0	0	0	0	0	0	0
lc	0.5	0.42	0.31	0.19	0.08	0.02	0	0	0	0	0	0	0	0	0
elp	0.35	0.35	0.35	0.35	0.35	0.35	0.35	0.35	0.35	0.35	0.35	0.35	0.35	0.35	0.35
ilp	0.35	0.35	0.35	0.35	0.35	0.35	0.35	0.35	0.35	0.35	0.35	0.35	0.35	0.35	0.35
leps	0.6	0.6	0.6	0.6	0.6	0.6	0.6	0.6	0.6	0.6	0.6	0.6	0.6	0.6	0.6
lts	0.45	0.46	0.43	0.35	0.23	0.1	0.03	0	0	0	0	0	0	0	0
ltp	0.35	0.27	0.17	0.08	0.02	0	0	0	0	0	0	0	0	0	0
ltd	0.35	0.27	0.18	0.09	0.3	0	0	0	0	0	0	0	0	0	0
ls_g	0.39	0.32	0.24	0.15	0.07	0.02	0.01	0	0	0	0	0	0	0	0
ls_s	0.28	0.22	0.15	0.08	0.3	0.01	0	0	0	0	0	0	0	0	0
lpa	0.3	0.19	0.1	0.04	0.01	0	0	0	0	0	0	0	0	0	0
llc	0.25	0.27	0.29	0.31	0.33	0.35	0.38	0.4	0.43	0.46	0.51	0.53	0.56	0.6	0.63
lale	0.25	0.27	0.29	0.31	0.33	0.36	0.38	0.41	0.44	0.47	0.51	0.54	0.58	0.61	0.65
lr	0.05	0.07	0.11	0.19	0.33	0.51	0.68	0.81	0.89	0.94	0.96	0.98	0.99	0.99	1
lbd	0.2	0.06	0.01	0	0	0.01	0.02	0.05	0.1	0.19	0.29	0.41	0.52	0.62	0.7
lgd	0.29	0.1	0.03	0.01	0.01	0.01	0.03	0.07	0.14	0.23	0.35	0.46	0.57	0.66	0.74
lbo	0.69	0.77	0.85	0.91	0.95	0.97	0.98	0.99	0.99	1	1	1	1	1	1
ldw	0.34	0.23	0.13	0.06	0.02	0	0	0	0	0	0	0	0	0	0

Attributes	15 iteration	16 iteration	17iteration	18 iteration	19 iteration	20 iteration	21 iteration	22 iteration	23 iteration	24 iteration	25 iteration	26 iteration	27 iteration	28 iteration	29 iteration
loe	0.94	0.93	0.91	0.9	0.88	0.85	0.82	0.79	0.75	0.7	0.64	0.58	0.51	0.43	0.36
lsv	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
lc	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
elp	0.35	0.35	0.35	0.35	0.35	0.35	0.35	0.35	0.35	0.35	0.35	0.35	0.35	0.35	0.35
ilp	0.35	0.35	0.35	0.35	0.35	0.35	0.35	0.35	0.35	0.35	0.35	0.35	0.35	0.35	0.35
leps	0.6	0.6	0.6	0.6	0.6	0.6	0.6	0.6	0.6	0.6	0.6	0.6	0.6	0.6	0.6
lts	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
ltp	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
ltd	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
ls_g	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
ls_s	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
lpa	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
llc	0.67	0.7	0.73	0.76	0.79	0.82	0.84	0.86	0.88	0.9	0.91	0.93	0.94	0.95	0.95
lale	0.68	0.71	0.74	0.77	0.79	0.83	0.85	0.87	0.89	0.9	0.92	0.93	0.94	0.95	0.96
lr	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1
lbd	0.77	0.82	0.87	0.9	0.92	0.94	0.96	0.97	0.97	0.98	0.99	0.99	0.99	0.99	1
lgd	0.79	0.85	0.88	0.91	0.93	0.95	0.96	0.97	0.98	0.98	0.99	0.99	0.99	0.99	1
lbo	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1
ldw	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0

Attributes	30 iteration	31 iteration	32 iteration	33 iteration	34 iteration	35 iteration	36 iteration	37 iteration	38 iteration	39 iteration	40 iteration	41 iteration	42 iteration	43 iteration	44 iteration
loe	0.28	0.21	0.14	0.09	0.05	0.03	0.01	0	0	0	0	0	0	0	0
lsv	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
lc	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
elp	0.35	0.35	0.35	0.35	0.35	0.35	0.35	0.35	0.35	0.35	0.35	0.35	0.35	0.35	0.35
ilp	0.35	0.35	0.35	0.35	0.35	0.35	0.35	0.35	0.35	0.35	0.35	0.35	0.35	0.35	0.35
leps	0.6	0.6	0.6	0.6	0.6	0.6	0.6	0.6	0.6	0.6	0.6	0.6	0.6	0.6	0.6
lts	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
ltp	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
ltd	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
ls_g	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
ls_s	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
lpa	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
llc	0.96	0.97	0.97	0.98	0.98	0.98	0.99	0.99	0.99	0.99	0.99	0.99	1	1	1
lale	0.96	0.97	0.98	0.98	0.98	0.99	0.99	0.99	0.99	0.99	0.99	1	1	1	1
lr	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1
lbd	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1
lgd	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1
lbo	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1
ldw	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0

Attributes	45 iteration	46 iteration	47 ire tation	48 iteration	49 iteration	50 iteration
loe	0	0	0	0	0	0
lsv	0	0	0	0	0	0
lc	0	0	0	0	0	0
elp	0.35	0.35	0.35	0.35	0.35	0.35
ilp	0.35	0.35	0.35	0.35	0.35	0.35
leps	0.6	0.6	0.6	0.6	0.6	0.6
lts	0	0	0	0	0	0
ltp	0	0	0	0	0	0
ltd	0	0	0	0	0	0
ls_g	0	0	0	0	0	0
ls_s	0	0	0	0	0	0
lpa	0	0	0	0	0	0
llc	1	1	1	1	1	1
lale	1	1	1	1	1	1
lr	1	1	1	1	1	1
lbd	1	1	1	1	1	1
lgd	1	1	1	1	1	1
lbo	1	1	1	1	1	1
ldw	0	0	0	0	0	0

2. Simulation results for attributes after adding the policy variable (attribute values are rounded off to two digits)

Attributes	1 iteration	2 iteration	3 iteration	4 iteration	5 iteration	6 iteration	7 iteration	8 iretaton	9 iteration	10 iteration	11 iteration	12 iteration	13 iteration	14 iteration
loe	0.85	0.94	0.97	0.99	1	1	1	1	1	1	1	1	1	1
lsv	0.58	0.64	0.69	0.73	0.76	0.79	0.82	0.84	0.86	0.88	0.9	0.91	0.92	0.94
lc	0.58	0.64	0.69	0.73	0.76	0.79	0.82	0.84	0.86	0.88	0.9	0.91	0.92	0.94
elp	0.35	0.35	0.35	0.35	0.35	0.35	0.35	0.35	0.35	0.35	0.35	0.35	0.35	0.35
ilp	0.35	0.35	0.35	0.35	0.35	0.35	0.35	0.35	0.35	0.35	0.35	0.35	0.35	0.35
leps	0.6	0.6	0.6	0.6	0.6	0.6	0.6	0.6	0.6	0.6	0.6	0.6	0.6	0.6
lts	0.49	0.55	0.61	0.67	0.73	0.78	0.83	0.87	0.9	0.93	0.95	0.96	0.97	0.98
ltp	0.27	0.2	0.14	0.09	0.05	0.03	0.01	0	0	0	0	0	0	0
ltd	0.28	0.21	0.16	0.11	0.08	0.05	0.03	0.02	0.01	0.01	0	0	0	0
ls_g	0.47	0.52	0.56	0.6	0.63	0.66	0.69	0.71	0.74	0.76	0.79	0.81	0.83	0.85
ls_s	0.36	0.42	0.47	0.51	0.54	0.58	0.61	0.64	0.67	0.7	0.73	0.75	0.78	0.81
lpa	0.34	0.38	0.4	0.43	0.46	0.49	0.52	0.56	0.59	0.62	0.66	0.69	0.72	0.75
llc	0.27	0.29	0.31	0.33	0.35	0.38	0.4	0.43	0.46	0.5	0.53	0.56	0.6	0.63
lale	0.27	0.29	0.31	0.33	0.36	0.38	0.41	0.44	0.47	0.51	0.54	0.58	0.61	0.65
lr	0.06	0.08	0.1	0.11	0.13	0.14	0.15	0.15	0.15	0.15	0.14	0.14	0.13	0.12
lbd	0.04	0	0	0	0	0	0	0	0	0	0	0	0	0
lgd	0.07	0	0	0	0	0	0	0	0	0	0	0	0	0
lbo	0.65	0.62	0.6	0.59	0.58	0.58	0.57	0.57	0.57	0.57	0.57	0.57	0.57	0.57
ldw	0.39	0.42	0.45	0.48	0.51	0.54	0.58	0.61	0.64	0.67	0.71	0.74	0.77	0.8

Attributes	15 iteration	16 iteration	17iteration	18 iteration	19 iteration	20 iteration	21 iteration	22 iteration	23 iteration	24 iteration	25 iteration	26 iteration	27 iteration	28 iteration	29 iteration
loe	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1
lsv	0.95	0.95	0.96	0.97	0.98	0.98	0.98	0.99	0.99	0.99	0.99	0.99	1	1	1
lc	0.95	0.95	0.96	0.97	0.98	0.98	0.98	0.99	0.99	0.99	0.99	0.99	1	1	1
elp	0.35	0.35	0.35	0.35	0.35	0.35	0.35	0.35	0.35	0.35	0.35	0.35	0.35	0.35	0.35
ilp	0.35	0.35	0.35	0.35	0.35	0.35	0.35	0.35	0.35	0.35	0.35	0.35	0.35	0.35	0.35
leps	0.6	0.6	0.6	0.6	0.6	0.6	0.6	0.6	0.6	0.6	0.6	0.6	0.6	0.6	0.6
lts	0.99	0.99	0.99	1	1	1	1	1	1	1	1	1	1	1	1
ltp	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
ltd	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
ls_g	0.87	0.89	0.9	0.92	0.93	0.94	0.95	0.96	0.97	0.97	0.98	0.98	0.99	0.99	0.99
ls_s	0.83	0.85	0.87	0.89	0.91	0.92	0.94	0.95	0.96	0.96	0.97	0.98	0.98	0.98	0.99
lpa	0.78	0.81	0.84	0.86	0.88	0.9	0.92	0.93	0.94	0.95	0.96	0.97	0.97	0.98	0.98
llc	0.67	0.7	0.73	0.76	0.79	0.82	0.84	0.86	0.88	0.9	0.91	0.93	0.94	0.95	0.95
lale	0.68	0.71	0.74	0.77	0.8	0.83	0.85	0.87	0.89	0.9	0.92	0.93	0.94	0.95	0.96
lr	0.11	0.11	0.1	0.09	0.08	0.07	0.07	0.06	0.06	0.05	0.04	0.04	0.03	0.03	0.03
lbd	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
lgd	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
lbo	0.57	0.57	0.57	0.57	0.57	0.57	0.57	0.57	0.57	0.57	0.57	0.57	0.57	0.57	0.57
ldw	0.82	0.85	0.87	0.89	0.91	0.92	0.93	0.95	0.96	0.96	0.97	0.98	0.98	0.98	0.99

Attributes	30 iteration	31 iteration	32 iteration	33 iteration	34 iteration	35 iteration	36 iteration	37 iteration	38 iteration	39 iteration	40 iteration	41 iteration	42 iteration	43 iteration	44 iteration
loe	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1
lsv	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1
lc	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1
elp	0.35	0.35	0.35	0.35	0.35	0.35	0.35	0.35	0.35	0.35	0.35	0.35	0.35	0.35	0.35
ilp	0.35	0.35	0.35	0.35	0.35	0.35	0.35	0.35	0.35	0.35	0.35	0.35	0.35	0.35	0.35
leps	0.6	0.6	0.6	0.6	0.6	0.6	0.6	0.6	0.6	0.6	0.6	0.6	0.6	0.6	0.6
lts	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1
ltp	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
ltd	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
ls_g	0.99	0.99	0.99	1	1	1	1	1	1	1	1	1	1	1	1
ls_s	0.99	0.99	0.99	0.99	1	1	1	1	1	1	1	1	1	1	1
lpa	0.99	0.99	0.99	0.99	0.99	1	1	1	1	1	1	1	1	1	1
llc	0.96	0.97	0.97	0.98	0.98	0.98	0.99	0.99	0.99	0.99	0.99	0.99	1	1	1
lale	0.96	0.97	0.98	0.98	0.98	0.98	0.99	0.99	0.99	0.99	0.99	1	1	1	1
lr	0.02	0.02	0.02	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0	0	0	0	0
lbd	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
lgd	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
lbo	0.57	0.57	0.57	0.57	0.57	0.57	0.57	0.57	0.57	0.57	0.57	0.57	0.57	0.57	0.57
ldw	0.99	0.99	0.99	0.99	1	1	1	1	1	1	1	1	1	1	1

Attributes	45 iteration	46 iteration	47 iteration	48 iteration	49 iteration	50 iteration
loe	1	1	1	1	1	1
lsv	1	1	1	1		1
lc	1	1	1	1	1	1
elp	0.35	0.35	0.35	0.35	0.35	0.35
ilp	0.35	0.35	0.35	0.35	0.35	0.35
leps	0.6	0.6	0.6	0.6	0.6	0.6
lts	1	1	1	1	1	1
ltp	0	0	0	0	0	0
ltd	0	0	0	0	0	0
ls_g	1	1	1	1	1	1
ls_s	1	1	1	1	1	1
lpa	1	1	1	1	1	1
llc	1	1	1	1	1	1
lale	1	1	1	1	1	1
lr	0	0	0	0	0	0
lbd	0	0	0	0	0	0
lgd	0	0	0	0	0	0
lbo	0.57	0.57	0.57	0.57	0.57	0.57
ldw	1	1	1	1	1	1

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A Methodology for Improving Strategic Decisions in Social Systems with a Lack of Information

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The design of strategies for social systems requires the use of qualitative information owing to the fact that quantitative information can be insufficient to solve the problems involved. The information that the specialists and the decision makers obtain is often incomplete and unreliable. Nevertheless, leaders have to make strategic decisions despite these deficiencies which should be based on the formal models (Kljajić et al. 2000; Škraba et al, 2003; Škraba et al 2007).
This paper describes a methodology elaborated to design the strategy of the city of Santa Cruz (on the Canary Islands). It has two main sections: the elaboration of a qualitative model and the use of System Dynamics. We combine them in a way that allows mixing qualitative and quantitative information to achieve a better understanding of the structure of the region, to know the tendencies of the present scenario and to estimate of the effects of alternative strategic decisions. We have obtained these results working with scarce quantitative information. This methodology may be applied to any social systems with similar characteristics.

Key words: Qualitative models, System Dynamics, Social Strategies

1 Introduction

This article is a continuation of a line of research (Kljajić et al. 2002, 2003a, 2003b; Legna Verna, 2000; Legna Verna and González 2004, 2006; Legna Verna et al., 2005a, b) aiming to help policy makers to improve the strategic decision-making process, in a context where there is a lack of information, particularly of a quantitative sort. When decision makers must make strategic decisions, usually the problem is complex and the available information is insufficient. Nevertheless, they must decide. Moreover, their strategic decisions deeply influence the future of their society and the well-being of its citizens. Taking into account this challenge, we have been working, alongside decision makers, to try to answer the following issues: a) how to integrate the available quantitative and qualitative information in a logical context; b) how to obtain a better understanding of the structural characteristics of the social system that influence its future; and c) how to estimate the impact of alternative strategic decisions.

As a response to these questions, we have developed a methodology that has been implemented in diverse regions and cities in order to design strategies. In this article, we present the methodology that we have designed to improve the strategic decision-making process of the city of Santa Cruz, Canary Islands, whose government requested the advice of our team of professors at La Laguna University (Guirao et al., 2007).

2 Methodology and results

2.1 First step: construction of the quality model

General characteristics of these models

Social systems are highly complex; to understand them in order to prepare decisions, particularly strategic ones, it is necessary to work with variables that are not quantitative with special attention to feedback system concepts (Sterman, 1994). Additionally, even in the case of quantifiable variables, researchers do not have sufficient information to build econometric relationships between them. These two restrictions may be overcome by the construction of qualitative models, such as the one that is presented in this chapter. It does not give precise

relationships between the variables, as is the case of econometric models, but allows one to understand the structure of the system and to detect the main relationships and roles of the variables.[1] In addition, it provides the basis for estimating the possible future path of the system and to build scenarios.

The general structure of the functions is the following: Y = f (X; V; Z; PolDec). This means that:

a) if an independent variable X (or V) increases at the rate X (or V), it will have a positive impact over the variable Y (where Y is the estimate rate of increase of the variable); and
b) if the independent variable (Z) is preceded by the minus sign, the impact will be negative.

X, V and Z are all independent variables, with different influence.

The weights of the impacts produced by the independent variables oscillate between 1 and 3; 3 is the stronger effect, 1 the weak and 2 medium. Research and interviews were made to assign these weights. When a variable is underlined, it means "increase rate", except for the variable "PolDec"; in this case, it ought to be understood as a decision (or a set of decisions) of the decision maker that will produce an impact over the dependent variable. In other words, "PolDec" means that a policy has been adopted and implemented (PolDec means Political Decision).

With qualitative models, the importance of precise data applied by the econometric and quantitative models is diminished and, evidently, we enter a more imprecise field. In this world, the relationships or equations, such as the ones that are presented in the next section, have to be understood as estimations of the direction (positive or negative) of the change of a dependent variable that is a consequence of a change of an independent one.

The relationships of the Santa Cruz's qualitative model.

The model has been built to answer the following questions: what are the main forces – and the feedback between them – that lead the transformation of Santa Cruz's economic system? What are the main policies that may be applied to these variables and feedbacks, with the aim of improving the quality of life of the population?

The model is organized in five blocks.

Block I: Employment

1) E = f (3 E-Com, 1.61 E-Const, 1.94 E-ServEnterp, 1.89 E-PA, 1.19 E-Educ, 1.23 E-TransCom, 1.08 E-SanitServ)

Where E= total employment in Santa Cruz; E-Com = employment in the commercial sector; E-Const = employment in the construction sector; E-ServEnterp = employment in the qualified services to enterprises and real estate services sector; E-PA employment in the public administration sector; E-Educ = employment in the education sector; E-TransCom = employment in the transportation and communication sectors; E-SanitServ = employment in sanitation services. The weights of independent variables were estimated as a function of the contribution of each sector to total employment. The sector with the largest contribution to employment has been given a weight of 3. Weights of other sectors have been established in proportion to this maximum.[2]

The functions of independent variables are the following (the sign * means "exogenous variable"; and AV means "added value", so AV-Com is the added value of the commercial sector):

2) E-Com = f (AV-Com);
3) E-Const = f (AV-Const);
4) E-ServEnterp = f (AV-ServEnterp);
5) E-PA*;
6) E-Educ = f (AV-Educ);
7) E-TransCom = f (AV-TransCom);
8) E-SanitServ = f (AV-SanitServ).

According to information available, the added value of the sector is the principal factor determining employment.

Block II. AV and AVpc (Total Added Value and Added Value per capita **in Santa Cruz)**

9) AV = f (2.77 AV-Com, 1.88 AV-Const, 3 AV-ServEnterp, 1.81 AV-PA, 1.50 AV-Educ, 2.60 AV-TransCom, 1.41 AV-SanitServ, 1.12 AV-Host, 1.87 AV-FinancInst);

This function is similar to the first equation, but in respect to the total added value. The sectors have been designated in a similar way to the ones of the employment block, replacing "E" with "AV". AV-Host is the added value of the hotel industry and AV-FinancInst is the added value of the finance sector. The weights have been calculated with the same formula used for the first equation, applied in this case to the added values.

The general criterion for the construction of the independent variables functions is that the AV of the sector depending on their demands and the quality of their offers (denoted "QualOf"). In others words, it means that the increase in economic activity in the city of Santa Cruz or in its environment (the rest of Tenerife) will produce an increase in the demand directed at their sectors. In general, the total added value of Santa Cruz (AV) and the total added value of the rest of Tenerife[3] have been used as indicators of their demands. In some cases (for instance the tenth equation), other indicators of demand have been used, but respecting the general criterion.

The "quality of offer" (QualOf) of a sector is defined as the result of the combination of: a) the variety of the products offered (for instance, the diversity of the services offered by the commercial sector); and b) the quotient between the quality of its products offered and its price. Consequently, the variable "QualOf" improves when either the diversity or the quotient increases. Therefore, to increase the value of this vari-

1 The literature on these models is large. See, for instance, Godet 1991a and 1991b and de Jouvenel, 1993. In Legna Verna, 2005: chapter I.1, the use of these models as a tool to prepare strategic decisions is studied.

2 The formula of the weight of the "i"-th sector is: (% of the employment – in respect to the total employment – in the sector that generates the maximum employment/% of the employment – in respect to the total employment – in the "i" sector)x3

3 Tenerife is the island where the city of Santa Cruz is located. More precisely, "rest of Tenerife" should be understood as Tenerife Island minus Santa Cruz.

able, it is necessary to introduce innovations in the sector and to elevate its labour productivity.

The increase of the Added Value of Santa Cruz (AV in the ninth equation) depends on the behaviour of other variables (the independent variables in the ninth equation), which have their own equations. They are the following:

10) AV-Com = f (PurchR; PurchNR), where PurchR = purchases made by the inhabitants of Santa Cruz and PurchNR = purchases made by inhabitant of the rest of Tenerife and tourists**;**
11) AV-Const = f (AV);
12) AV-ServEnterp = f (AV; AVt; QualOfServEnterp);
13) AV-PA*;
14) AV-Educ = f (Prsc; Prnsc) or Prsc = inhabitant of Santa Cruz and Prnsc = population that has its residence near Santa Cruz and that use education services located in this city;
15) AV-TranspCom = f (AV; AVt; QualOfSerTranspCom);
16) AV-SanitServ = f (AV; AVt; QualOfSSS), where QualOfSSS = quality of the offer of sanitation and social services;
17) AV-Host = f (NightT), where NightT = Number of nights that tourists have been lodged in hotels of Santa Cruz, per year;
18) AV-FinancInst = f (AV; AVt; QualOfFinancInst);
19) QualOfSSS* ;
20) QualOfTransCom* ;
21) QualOfFinancInst* ;
22) PurchR = f (AV; QualOfCom)
23) PurchNR = f (AV-t; TR; QualOfCom; LifeQ), where TR = the total revenue left by tourists that visit Tenerife per year (medium revenue multiplied by the number of tourists) and LifeQ = the quality of life of inhabitants of Santa Cruz (that will be definite in Block III;
24) QualOfCom*;
25) AVt*;
26) TR*;
27) QualOfServEnterp* ;
28) NightT = f (AV; LifeQ; QualOfHost) ;
29) QualOfHost*; and
30) QualOfSSS*.
31) AVpc = f (-0.8 AV-Com, -0.2 AV-Const, 0.5 AV-ServEnterp, -0.5 AV-PA, 1.6 AV-TransCom, 0.2 AV-Host, 2.5 AV-FinancInst, 0.7 AV-ProdDistW, -0.2 AV-OtherSServ, 3 AV-ExtProdEner)

According to this function, the added value per worker employed in Santa Cruz either increases or decreases if the weights of the independent variables are positives or negatives. The signs of theses weights depend on the relationships between two quotients: AVpci = (added value by the sector / number of worker in the sector); and AVpc= (total added value in Santa Cruz/total number of workers); i.e. the average labour productivity of the city. If AVpci>AVpc, an increase of the added value of the sector "i", will increase AVpc.[4] This is the reason the sign of its weight is positive. The same reasoning explains the negative values. The absolute values of the weights have been calculated in the function of the contribution of each sector to the total employment and the difference between AVpc and AVpci. An equation such the 30th one is very important in regards to the elaboration of strategies, because it allows the detection of sectors whose increases have stronger effects on the elevation of productivity of the labour force, and therefore, their wages. We have been obliged to adopt the explained form of this equation due to the scarcity of statistics.

The equations of the independent variables that were not definite previously, are the following:

51) AV-EnergProd* = Added Value of Energy Production Sector;[5]
53) AV-OtherSServ = Added Value of Other Social Services Sector= f (AV; QualOfOtherSS);
54) AV-ProdDistW = Added Value of the Production and Distribution of Water Sector = f (AV; Prsc).

Block III: Quality of Life

27) LifeQ = f (-Delinq, -Drug, AdmDesc, -AcPoll, -TrafficProb, Anaga, LeisureLitt, EquipColect, PublicServEfic, HistPatrim, CityClean, AVpc, E)

The independent variables of this equation are the urban and social problems that concern the inhabitants of Santa Cruz and additional two: the total employment and the added value by worker. These two last are included in the equation because of their impact on the revenue of the population. The first group of variables has been selected based on a poll conducted in the city (Ayuntamiento de Santa Cruz de Tenerife, 2006).

The definitions of the new variables are the following:

31) Delinq = Delinquency and insecurity = f (PolDec, ME, PublicServEfic), where ME = Municipality Expenses and PublicServEfic = Efficiency of the delivery of the public services. This equation means that delinquency and insecurity are reduced if the local government implements new policies to solve these problems, increases municipal expenses or augments the efficiency of the services to resolve them. The same formula has been adopted for the following equations, excepting equation number 39.
32) Drug = Drugs = f (PolDec, ME, PublicServEfic);
33) AdmDesc = Administrative Decentralization = f (PolDec, ME, PublicServEfic);
34) AcPoll = Pollution of the environment due to the noise = f (PolDec, ME, PublicServEfic)**;**
35) TrafficProb = Traffic problems = f (PolDec, ME, PublicServEfic);
36) Anaga = Quality of the environment in Anaga (this is an area visited by the population for leisure activities) = f (PolDec, ME, PublicServEfic);

4 This reasoning is *ceteris paribus*, which is to say that the other independent variables are constant. Consequently, it implies that the weight of the sector increases.

5 The numbering of the equations corresponds to their position in the matrix used to perform the analysis of the role of the variables. The construction of the matrix is explained in Annex. Equations are grouped and referenced in blocks, in order to facilitate the understanding of the structure of the model.

37) LeisureLitt = Offer of services and infrastructures for leisure activities on the Santa Cruz coast = f (PolDec, ME, PublicServEfic);
38) PublicInfrast = Offer of public infrastructure = f (PolDec, ME, PublicServEfic);
39) PublicServEffic = f (PolDec);
40) HistPatrim = Conservation and quality of the historic heritage and the degree to which it is accessible to the population = f (PolDec, ME, PublicServEfic);
41) CityClean = Cleanliness of the city = f (PolDec, ME, PublicServEfic); and
42) PolDec*

The meaning of these equations is that if problems such as cleanliness, delinquency, unemployment, etc. are reduced and employment and the productivity of labour rise, the quality of life of the city will increase. It is important to note that the improvement of the quality of life is, at the same time, an attraction to tourists and inhabitants of Tenerife, because it stimulates them to come to the city and to increase their purchasing.

Block IV. Budget and municipal expenses.

43) ME = f (DME, MRT, MRX, PolDec)

The rate of increase of municipal expenses (ME) depends on the increase in the value of the demands that the population makes on the municipality (DME), the revenues of the municipality obtained through taxes (MRT), other revenues obtained through transfers of external institutions (MRX) and on the implementation of municipal policies (PolDec). It is important to note that MRT depends on the general economic activity of the city, creating a feedback between the expenses of the municipality and economic development.

The other functions of this block are the following:

44) MRT = f (FP, AV), where FP = fiscal pressure = total value of paid taxes /AV;
45) FP = f (PolDec, AV);
46) DME = f (Prsc, Prnsc, VNR) where VNR = number of visitors to the city per year;
50) VNR = f (AV, LifeQ);
47) MRX*;
52) DissatDem = f [(DME-ME); -PublicServEfic)], where DissatDem = degree of dissatisfaction of Santa Cruz inhabitants with respect to the problems (delivery of services, reduction of pollution and traffic problems, etc.) that they want solved by the local government.

Block V. Population

48) Prsc = f (E, LifeQ). This means that the population of Santa Cruz depends on total employment and quality of life.
49) Prnsc = f(E) population located in zones near Santa Cruz is a function of employment in the city.

The model has some significant feedback between the blocks (or subsystems). The variables "Employment", "Total added value" and "Added value per capita" of Blocks I and II produce effects on Subsystems III (quality of life) and IV (the municipality budget). The increase (decrease) of the variables of the two first blocks affects the quality of life and the municipal budget and expenses. In turn, these variables react and affect the first ones. In respect to the population, it is determined by the economic development and quality of life of the city; in turn, its augmentation increases the demand for municipal expenses and the pressure on the city. This pressure aggravates some environmental problems, such as pollution, which require additional municipal expenses to be solved.

Analysis of the roles of variables in the system

A typology of variables may be distinguished[6]:

a) Leading variables, which produce strong impacts on the other variables of the system yet are not significantly affected by their changes – directly or indirectly;
b) Interacting or feedback variables, which both produce – directly or indirectly – important impacts over the others and are also affected by their changes;
c) Dependent variables, which are the contrary of the first group because they are very sensitive to the changes of the other variables but do not produce important effects over them; and, finally,
d) Variables that may be discarded, because they neither produce nor receive important effects.

The roles of variables in the Santa Cruz model have been detected by applying the methodology of analysis of leading and depending forces.[7] Their roles are presented in Figure 1, in which the horizontal axis expresses the dependency of the variables and the vertical, their leading force. If its horizontal value is high for a variable, this means that it is strongly affected by the changes in the other variables of the system; if its vertical value is high, this means that its changes produce strong impacts on the other variables. The leading variables have a high value in the vertical axis and a low value in the horizontal one; however, the dependent variables have a high dependency and a low leading force. The feedback variables have high values in both the vertical and horizontal axis.[8] They strongly interact and produce feedback processes in the system. Consequently, they may multiply the initial changes produced in one or some variables, pushing the system out of its previous state.

In Figure 1, the leading variables (LV) are in the first quadrant. They are the added values of a set of branches, between which three sub-groups may be distinguished:

a) LV1 (in green), that includes qualified "Services delivered to enterprises and real estate services" (AV-ServEnterp), "Transports and Communications" (AV-TranspCom), and "Financial services" (AV-FinancInst);
b) LV2 (in red), "Commerce" (AV-Com), "Construction" (AV-Const) and "Public administration" (AV-PA); and,
c) LV3 (in black), "Education services" (AV-Educ). In spite of the fact that they are not in the first quadrant, we consider that the added values of "Sanitation and other social services" (AV-SaniyServ) and "Hotel industry" (AV-Host) are leading forces, because they have important values in

6 See, for instance, Legna Verna, 2005: chapter I.2 and Roubelat, 1993: 258.
7 See Legna Verna, 2005: chapter I.2
8 See Annex

the vertical axis. Evidently, their leading power is weaker than the preceding ones. It is also important to note that "Financial services", "Transport and Communications", "Delivery of services to enterprises" and "Sanitation and other Social Services" have an important dependency and, consequently, they play an interacting role in the system. In fact, the role of these four variables is not easy to classify neatly. We may consider them both as "interacting variables with a high degree of leadership" or "leading variables with a high degree of interaction".

In the second quadrant are the strictly interacting variables (IV). In this model, there is only one variable pertaining to this category: the value added of the city, which has a very strong leading force and dependency.

Usually, in the leading and dependency analysis, the dependent variables (DV) are the ones that fall in the third quadrant. Nevertheless, in the study of the Santa Cruz model we have included in this category of variables some other ones that are in the fourth quadrant, because they have an important value in their horizontal. They are in the fourth quadrant because AV has a high value of dependency and displace to the right the vertical line separating the quadrants. The dependent variables have been classified into three categories:

a) DV1, the per capita added value of Santa Cruz (AVpc) and the quality of life ((LifeQ);
b) DV2), the demands that the population make on the municipality (DME), the revenues the municipality obtains through taxes (MRT) and fiscal pressure (FP);
c) DV3) the number of nights per year that tourists have been lodged in Santa Cruz (NightT), the number of visitors that came to the city per year (VNR) – an indicator of the external demand made on what the city offers, particularly on the commercial sector – and the purchases made by the inhabitants of Santa Cruz (PurchR).

The colours assigned to the abbreviated names of the variables have different meanings: green means that the productivity of the labour force working in the sector is superior to the city average; red means that the productivity is lower; and black means that it is approximately equal to the average. Productivity is defined as follows: AVi/Ei, where AVi = added value of the "i" sector and Ei = number of persons working in the same sector "i". Therefore, if the share of the employment of a green sector increases in respect to the total employment of the city, it produces an augmentation of the average labour productivity; and it decreases if a red sector has a higher weight.

The preceding analysis allows an understanding of the structure and functioning of Santa Cruz's system. The increase (or decrease) of activity in leading sectors – services to enterprises, transport and communication, finance, construction, commerce, public administration and education – augments (or reduces) the total employment and the added value of Santa Cruz. These last two sectors return the effects, producing an increase (decrease) of the activity of the leading forces, particularly in services to enterprises, finance and transport and communication, which have an important dependency value. However, these are not the only loops. The general increase (decrease) of economic activity and employment produces an increase in revenue for the city's public budget, which in turn satisfies the population's demands and improves quality of life. In turn, the improving quality of life generates a new wave of effects: because it is an attraction for foreign visitors, demand on the city's production sector increases. If the more dynamic sectors are the "green" ones, which have a high productivity, there will be a general increase of per capita revenue. It follows that policies oriented towards the increase in added value of services to enterprises, finance, transport, and communication are crucial; it is likewise important to increase the productivity of certain sectors, such as commerce, which have an important weight in the employment sector but do not have a high labour productivity.

2.2 Second step: identification of the main characteristics of the tendency scenario

The first step of the methodology detects the main variables that lead the system. On the basis of this result, the second step focuses on the analysis of the tendencies of these variables, to obtain information about the **direction** that the system is taking. If it is going in a negative direction, it will be necessary to design a strategy with the aim of changing this direction. If it is going in a positive one, the strategy will be orientated to reinforcing the direction.

The tendencies that affected Santa Cruz in the last decades produced a decline in the relative significance of the city, both in the context of Tenerife Island and of the Canary Islands Region (more information about this section can be found in Guirao 2007).

The ratio of Santa Cruz's population to the total population of its island and to the total of the Canary Islands has been decreasing. More importantly, according to the Statistics Institute of Canary Islands (ISTAC), the population of the city is projected to decrease in the future, from 203,795 inhabitants in 1996 (1st. January) to 184,430 (1st. January) in 2011[9]. The same tendencies affect both the number of persons who pay the revenue tax and therefore the fiscal revenues generated by it (Table 1). For instance, the number of persons who declared this tax increased in Santa Cruz by 29% between 1991 and 1998 while it increased more than 80% in Tenerife and in the Canary Islands during the same period. The same tendency is observed for the fiscal revenues generated by this tax. It is a good indicator of the general reduction of the weight of economic activity in relation to both Tenerife and the Canary Islands region.

Nevertheless, not all economic activities have been affected by the tendency to decline. Some have been resilient, as may be observed in Table 2, which shows the rates of increase in employment in Santa Cruz, Tenerife and Canary Islands, between 1999 and 2002. In this table, the sectors have been differentiated with colours according to their role and their rate of increase of employment. In the first column, the coloured ones are the leading sectors; green indicates that the labour productivity is higher than the average; red that it is lower than

9 The information of the ISTAC was obtained from its web page, on 09/02/2005.

Table 1: Increase (in %) of the persons that pay the IRPF (revenue tax on physical persons[10]) and of the fiscal revenues generates by this tax, between 1991 and 1998

-	Increase, in %, of the number of persons that pay the IRPF	Increase, in %, of the fiscal revenues due to the IRPF
Santa Cruz de Tenerife	29.43	9.20
Tenerife Island	88.10	31.51
Grand Canary Island	81.26	29.99

Source: calculations made on the basis of data of the "Avance del Plan Estratégico de Tenerife"

average; and black that it is similar to the average. In the other columns, green means a rate of increase of the employment higher than the average; light green that it is approximately similar to the rate of Tenerife and Canary Islands and red that the rate is lower in Santa Cruz.

Regarding the more productive leading sectors, it may be observed that Santa Cruz loses weight in "Hotel Industry" and "Financial Services"; but "Transports and Communications", and "Services provided to Enterprises and Real Estate Services", maintain their relative weight. This same behaviour is observed in two sectors with low labour productivity but that are important from the point of view of the generation of employment: commerce and construction. Finally, both "Public Administration" and "Education", which have labour productivity similar to the average, lose their participation.

Evidently, Santa Cruz is not going in the right direction. The third step of the methodology is oriented to study the effects of alternative strategy decision to lead the system to the desired scenario.

2.3 Third step: application of System Dynamics to the relationships of the qualitative model and estimation of the impacts of alternative strategies.

The qualitative model and the analysis of leading and depending forces allow the selection of the relevant variables

Table 2. Rate of increase of employment of the branches between the third term of 1999 and 2002

Branches	St. Cruz	Tenerife	Canary Is.
A. Agriculture and cattle	1.33	1.13	1.08
B. Fishing	0.60	0.75	0.70
C. Extractive Industries	1.36	1.18	1.24
D. Manufacturing industry	1.01	1.06	1.03
E. Prod. and distrib. of electric energy, gas, steam and hot water	0.87	0.98	0.94
F. Construction	1.22	1.25	1.21
G. Commerce, repairing of vehic. and other articles.	1.16	1.16	1.16
H. Hotel industry	1.04	1.12	1.14
I. Transports, storing and communications.	1.07	1.08	1.05
J. Financial services.	1.06	1.08	1.1
K. Serv. to enterprises and real estate services.	1.21	1.23	1.21
L. Public, administration, defence and social services	1.17	1.19	1.11
M. Education	0.94	1.04	1.04
N. Sanitation and veterinary serv. and other social services	1.02	1.1	1.15
O. Social activ., services to the community and personal services	1.14	1.23	1.25
P. Personal services provided at homes	1.19	1.14	1.18
Q. Employment in extraterritorial organizations	1.75	1.6	1.19

The calculations where made using the statistics of the ISTAC. The values in columns 3, 4 and 5 are equal to: Ei2002/Ei1999, where Ei2002 = employment in the sector "i" during the third term of 2002 and the same definition for Ei1999.

10 In Spanish IRPF = Impues to a la Renta de Personas Físicas.

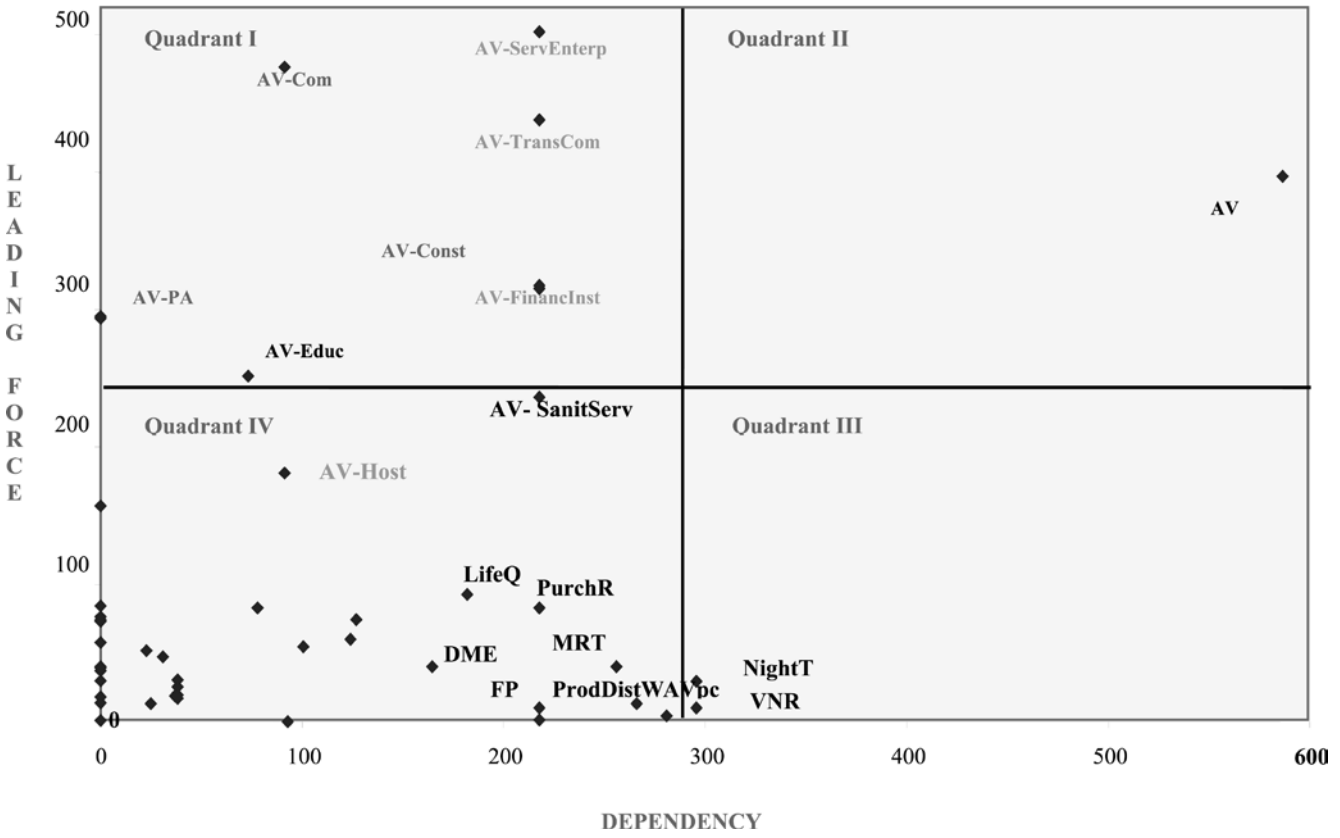

Figure 1: Variables leading and dependency force

and the detection of their role in the system. This is an important step in order to make decisions.

Figure 2 represents causal loop diagram (CLD) of aggregated model. The most important variable in the model is life quality, which is the main variable in the system. An increase in life quality increases the added value and quality of services above the level that it would otherwise have been. This positively influences the productivity and improves human capital as well as life quality. Life quality also positively influences the level of education, which contributes to the preservation of natural resources as well as the improvement of human capital. The described causal loop has a positive character which leads to self improvements of the system. However, one should also consider the limitation of natural resources, which are also shown in the diagram. An important strategic point that is revealed by the model is the following: to improve the quality of life of the citizens it is not only important from the point of the well being of the citizen but is important too from the point of view of the economic activity. So, the quality of the city (low pollution, crimes, transport problems, etc.) and its economic growth go in the same direction. There is no a trade off between environment and quality of life of the city and economic activity.

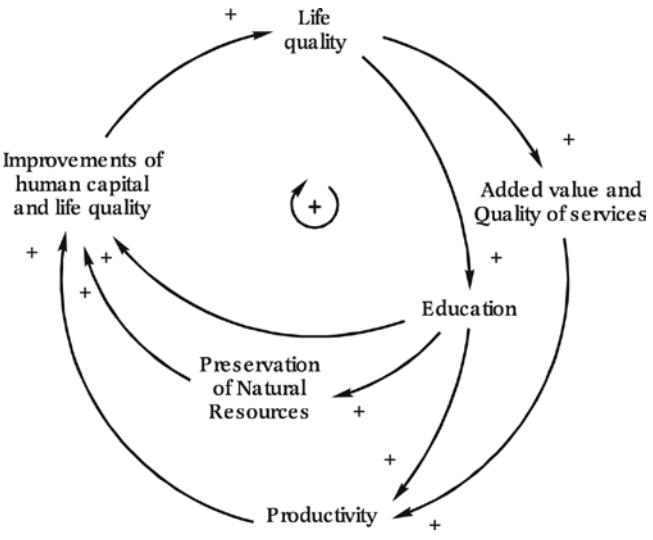

Figure 2: Causal Loop Diagram of aggregated model

A further step can be taken that consists of the application of system dynamics to the variables and the relationships of that model. Using Powersim software, the qualitative model was "translated" into a system dynamics model. Figure 3 presents the relationships that generate the increase in quality of life (LifeQ); Figure 4 in employment (E°); Figure 5 in per capita added value (AVpc°); and Figure 6 in total added value of Santa Cruz.

Simulations were conducted to estimate the effects of various decisions, each one implicating the adoption of a strategic option. For example: one option may be to opt for a higher specialization of Santa Cruz in the commercial sector; a second one is a higher specialization in qualified services to

enterprises; a third one is an increasing specialization in financial services, and so on.

If the first option is chosen as opposed to the second, the rates of increase in quality of life, the added value per capita, and the added value in the qualified services to enterprises sector will all be lower; in turn, the rates of growth in employment and the added value of the commercial sector will be higher. In other words, each strategic option steers the city towards two different scenarios: one characterized by higher qualified labour with elevated productivity and, another, by the opposite.

3 Discussion

The methodology that has been explained in this article helps to improve the decision-making process in a variety of ways. It permits a better understanding of the relevant characteristics of the structure of the social system and the role of the main variables in it. With this information, the specialists and the decision makers will know in which direction the changes of the variables will lead the system. Moreover, they will know which variables are strategic, because their changes will produce the strongest effects. If it is possible, the strategy has to implement policies to change the behaviour of these variables. In the case of the ones that are not possible (for example, the GDP of Tenerife Island is an exogenous variable that has an important impact on the evolution of Santa Cruz), the specialists and the decision makers know that they have to constantly predict their evolution. With this information, they will be better equipped to design policies orientated to mitigating the undesirable impacts of the evolution of these variables and to improving the positive effects. For instance, the present economic crisis has been producing a reduction in the number of tourists that visit Tenerife and, consequently, a decline of its GDP. In turn, it has produced a decline of the GDP of Santa Cruz and an increase in unemployment. Knowing these relationships, our team, working along with the authorities, has designed policies to reduce the negative impacts of the evolution of this variable.

With respect to the analysis of the alternative strategic decisions, it is important to emphasize that the methodology permits the prediction of the directions that the system will take as a consequence of these decisions. They are not quantified projections. They only provide the decision makers with information that allows them to visualize in which direction the system will move as the result of the implementation of a strategic decision. If the decision makers have selected a desired scenario, this approach allows them to determine if a particular strategic decision leads the system in the direction of it.

The application of system dynamics is also useful in estimating the effects of the hypotheses adopted and the changes of the preferences of the population with the purpose of selecting the strategy. Because of the lack of information, it was initially supposed that the population assigned the same importance to the level of employment and the per capita added value as variables that determine his level of quality of life (between others). The following step consisted of performing simulations that assigned different weights at these two variables. These simulations made it possible to appreciate that if the population considers the per capita added value to be more important than the level of employment, a strategy that accelerates the growth of sectors such as "Services to enterprises and real estate services" would be preferable than a strategy that accelerate the increase of "Commerce". On the contrary, it would be preferable to give priority to this sector if the population valued employment more than its per capita revenue. This approach allows performing analysis of the kind "What happens if…?" (for example, environment becomes a more valued variable, etc.). At present, these studies are being carried out in conjunction with the authorities of Santa Cruz.

4 Annex

The equations of these qualitative models may be written as a matrix. If they are the following: 1) A = f(2B; C), 2) B = f(C) and 3) C = f (3B) the associated matrix (M) is

	A	B	C	Σ
A	0	0	0	0
B	2	0	3	5
C	1	1	0	2
Σ	3	1	3	

For instance, column A has a 2 in line B and a 1 in line C, because A is affected by the changes of B and C (and it is

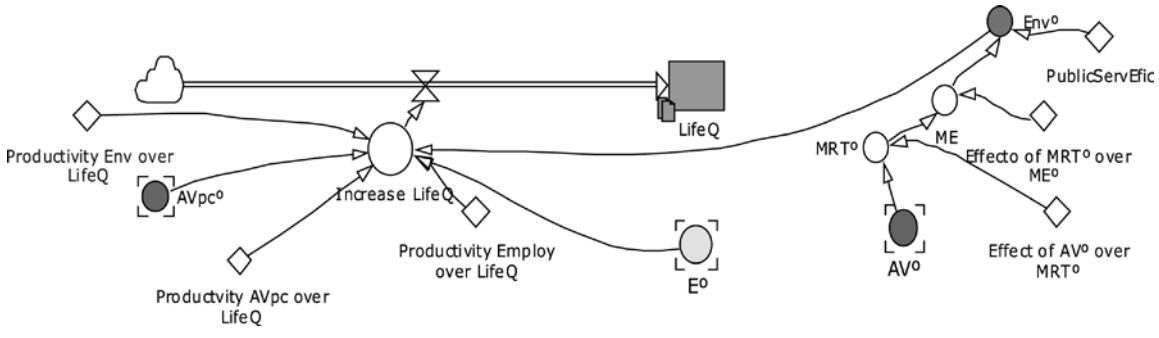

Figure 3: Relationships that generate the increase in quality of life (LifeQ)

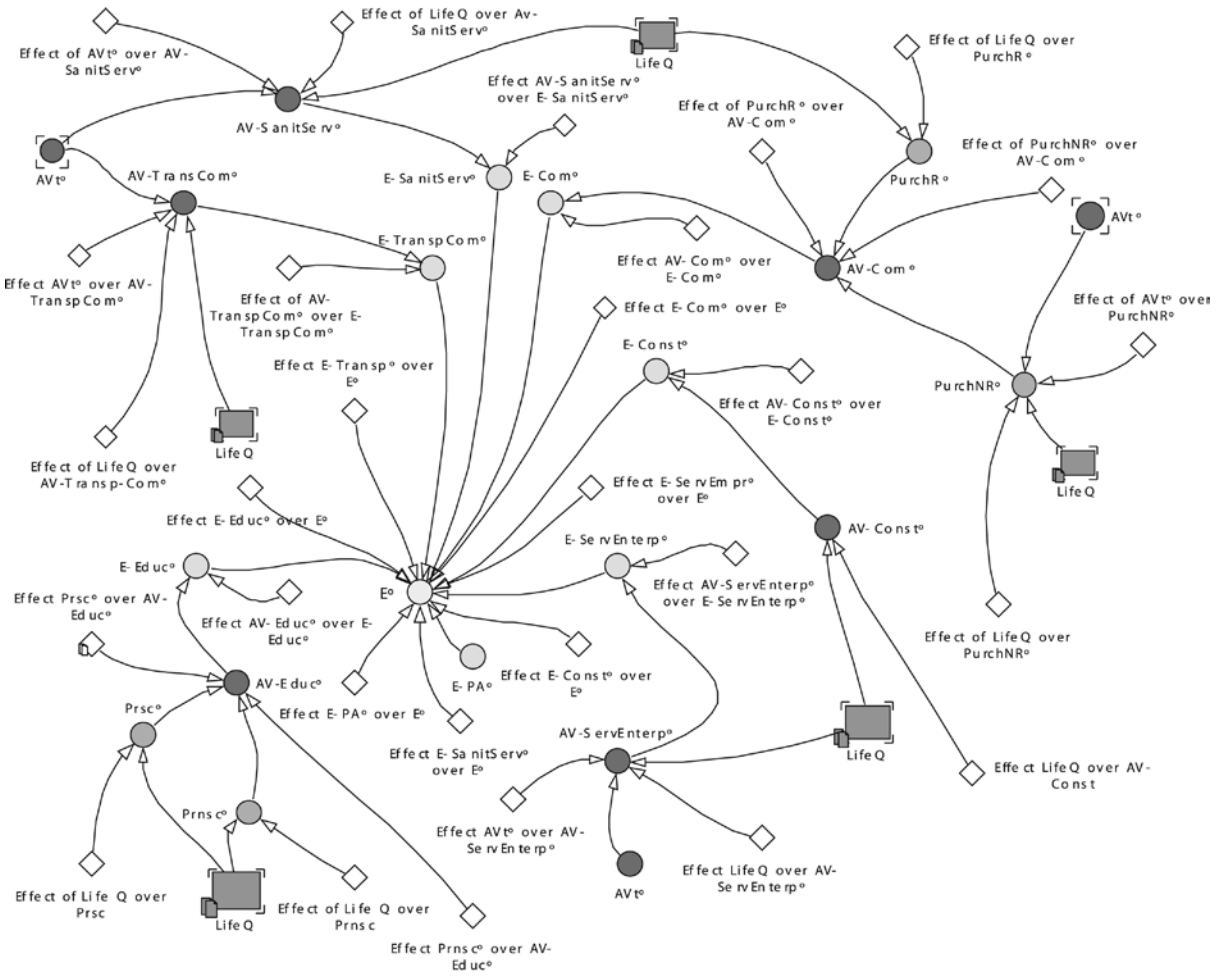

Figure 4: Employment (E°) subsystem

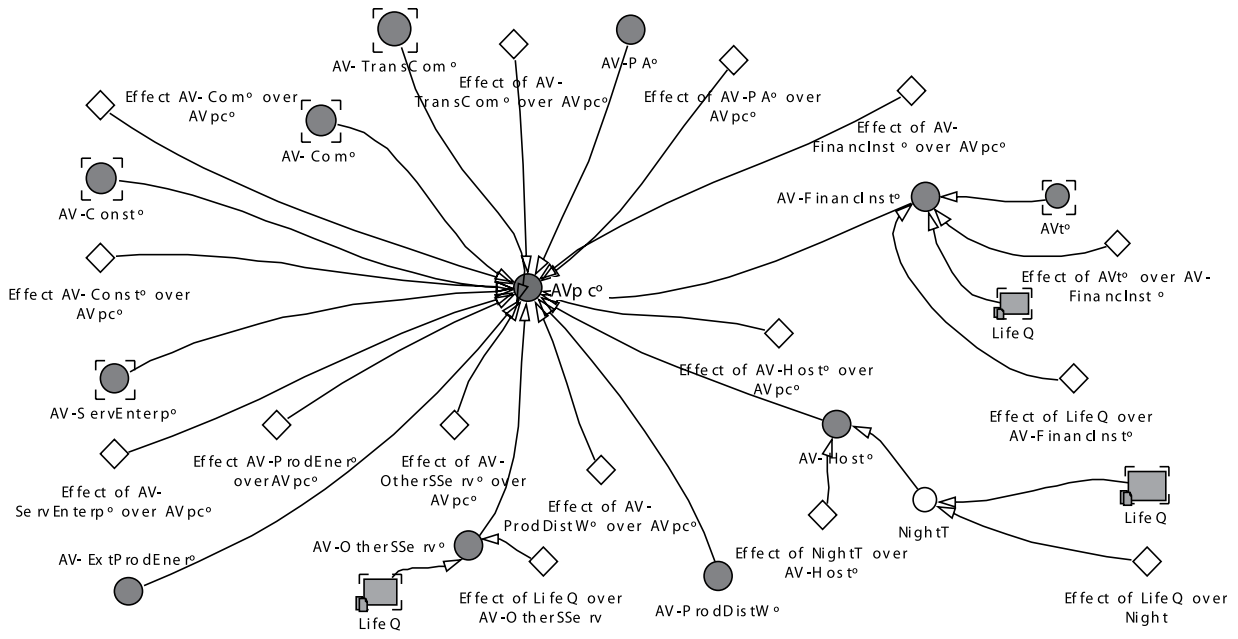

Figure 5: Per capita added value (AVpc°)

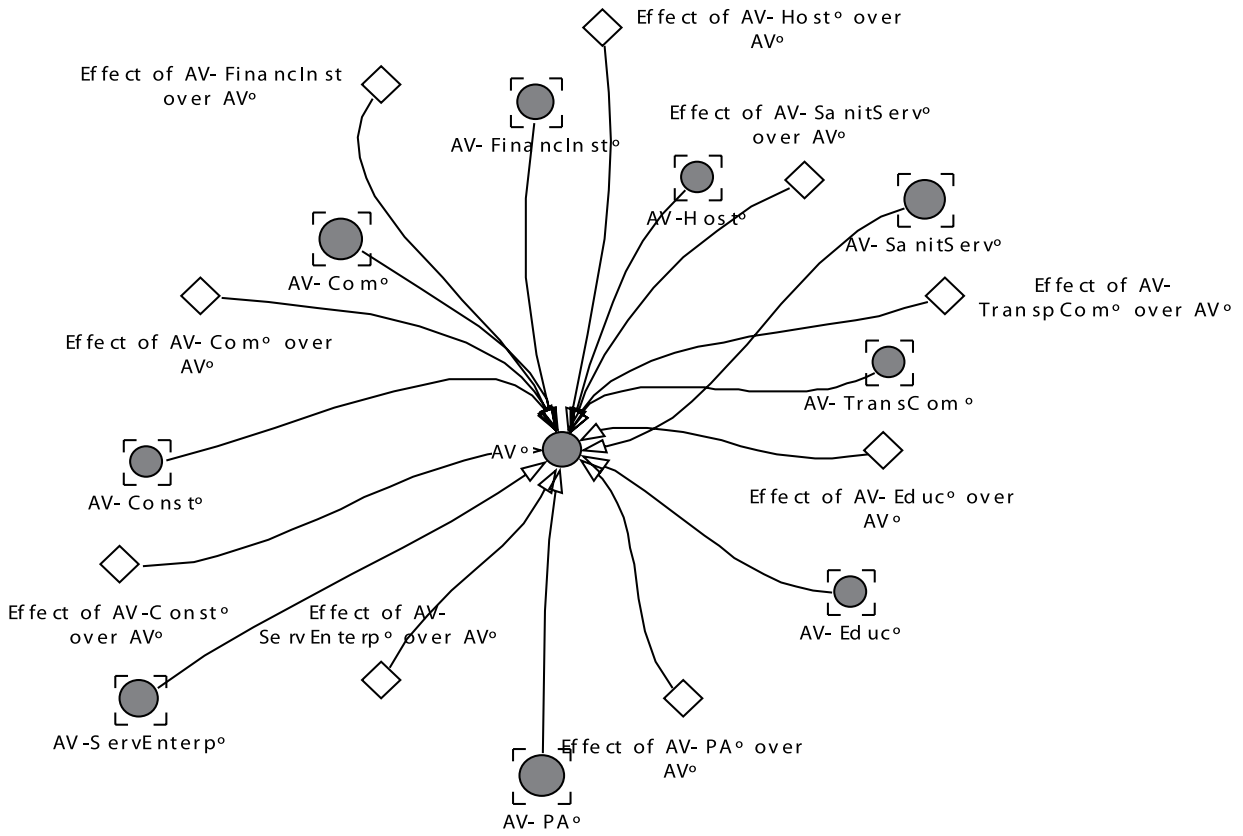

Figure 6: Total added value of Santa Cruz

estimated that a change of B produces a change in A that is double than the change in A due to a change in C). In general, if case $x_{ij} = 1$, it means that a change in variable i produces a change in j. If it is equal to zero, there is no effect from i to j. Consequently, the sum of the cases of the line of a variable is its leading force; the sum of the cases of its column indicates the dependency of the variable. For instance, variable A is essentially dependent, because the sum if its column is 3 and the sum of its line is 0; in contrast, B is a leading variable. Therefore, this matrix M allows the detection of the **direct** effects between the variables. Nevertheless, in social systems the **indirect** influences are important, which are detected by the multiplication of M. It may be demonstrated that if M is elevated at two, each case aij of the new matrix (M^2) includes the effects that pass through one variable: $X_i \rightarrow X_u \rightarrow X_i$, X_u being in this case the intermediate variable (Legna Verna, 2005: chapter I.2). If the matrix is elevated at four (M^4), it will reveal the effects that pass through three intermediate variables, and so on. In the case of this work, we elevated M at four. Figure 1 represents, for each variable, the sums of its line (vertical axis) and of its column (horizontal axis) in M^4. Consequently, the vertical axis of Figure 1 indicates the leading force of a variable and the horizontal its dependency. With regard to units, if a case of M^4 is $x_{ij}^4 = 1$, it means that there is one path $X_i \rightarrow X_u \rightarrow X_v \rightarrow X_w \rightarrow X_j$ that "transits" the effect of the change initiated in X_i until it produces a change in X_j. If it is 2, there are two paths, and so on. This result is valid only if the matrix M has merely values of one and zero. If the cases have other values (for instance, twos and threes) the figures of the cases indicates the relative force of the indirect effects of i over j.

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Metodološki pristop k izboljšavam procesov strateškega odločanja v družbenih sistemih ob nepopolnih informacijah

Oblikovanje strategij na področju družbenih sistemov zahteva uporabo kvalitativnih informacij, saj nabor razpoložljivih kvantitativnih informacij v večini primerov ni zadosten za celovito rešitev aktualnih odločitvenih problemov. Informacije, ki so na voljo strokovnjakom in tistim, ki se odločajo, so največkrat nepopolne in nezanesljive. Ne glede na to, morajo vodje sprejeti strateške odločitve, navkljub omenjenim pomanjkljivostim. Prispevek obravnava metodologijo, ki je bila razvita za potrebe strateškega odločanja v mestu Santa Cruz na Kanarskih otokih. Prispevek ima dva ključna dela: opis kvalitativnega modela in uporaba sistemske dinamike. Pri tem je izvedena kombinacija metodologij, ki omogočajo ustrezno prepletanje kvalitativnih in kvantitativnih informacij z namenom doseči boljše razumevanje strukture obravnavane regije, tendence trenutnih scenarijev in izvedbo ocene učinkov alternativnih strateških odločitev. Predstavljeni rezultati so pridobljeni na omejenem naboru kvantitativnih informacij. Opisano metodologijo je moč uporabiti na kateremkoli družbenem sistemu s podobnimi karakteristikami.

Ključne besede: kvalitativno modeliranje, sistemska dinamika, strateške odločitve

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The COMPRAM Methodology and Complex Societal Problems – an Analysis of the Case of Children Born of War

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During and after wars children are born where the father is a member of an occupation or peacekeeping force and the mother a local citizen. Securing the human rights of children born of war is often highly complex and involves researchers and practitioners from different disciplines. The Compram methodology on handling complex societal problems will be applied to analyse whether the methodology is suitable on this group of war-affected children. The Compram methodology is a multi disciplined, multi level, multi actor methodology based on the theory of societal complexity. The methodology gives guidelines to handle real life complex societal problems.

Keywords: OR in societal problem analysis; Taboo research; COMPRAM methodology; children; war.

1 Introduction

In this article we will analyse the applicability of the Compram methodology to the group of children born of war. Children born of war are children born during and after wars and conflicts where the father is or has been a member of an enemy, allied or peacekeeping force and the mother a local citizen (cf. Grieg, 2001:6, Mochmann, 2006:198)[1]. The Compram methodology is a method for handling complex societal problems in a transparent and structured way developed by DeTombe (1994, 2003). The Compram methodology can be applied to a variety of complex societal problems; natural problems such as flu pandemic, earth quakes and floods as well as man-made problems like terrorism, healthcare problems and agricultural problems. The research question is: Is the Compram methodology applicable to a war affected, hidden and marginalised population as that of the children born of war? The fact that children are born who have parents from two opposing sides of a conflict is not a new phenomenon of modern warfare. There have always been children born as a result of either consensual relationships or sexual exploitation and rape during and after wars. Kuwert and Freyberger (2007) point out that sexual violence against women and women as part of war booty are even found in mythology as well as in several parts of the Bible. Remarkably little is known about the children born out of such relationships. To the best of our knowledge the children are addressed for the first time in connection with World War I in Magnus Hirschfeld's book *The Sexual History of The World War* (Grieg, 2001:21). Explanations for this lack of attention devoted to children born of war both among academics and practitioners are at least threefold:

1. *There are not many children born of war.* Looking at the estimated number of children born of war during World War II and thereafter clearly falsifies this assumption. An estimate by Grieg (2001:8ff) indicates that from 1945 until 2001 more than 500.000 children born out of relationships with foreign soldiers and local women were born. The conflicts range from World Wars I and II to wars in Vietnam and Bangladesh in the 1960s and 70s to Bosnia and Rwanda in the 1990s. Taking into account that many women hide the real origin of their children because they are ashamed or fear stigmatisation the number is probably much higher. Also abortions and infanticides are likely to have taken place. Finally, children are still

1 Often the term "war child" is used when describing this group. This is an ambiguous concept which is used also to describe other war affected children. A group of researchers thus decided at the meeting "Consolidating the evidence base of children born of war" in Cologne in 2006 to apply the term "children born of war" for this particular group of children. For further details see Mochmann (2006, 198f.)

being born in present and ongoing conflicts so the overall number is thus higher.

2. *The children born of war do not differ from other children of their home country*. Their biological background does not matter and therefore does not need special attention. In some cases this may be the fact. However, information available from several wars indicates that many children born of war are exposed to discrimination and stigmatisation both within family, community and society. Problems range from the rejection by close relatives to the lack of citizenship.
3. *The topic is taboo both within family and community*. If the topic is a taboo then information is less likely to reach the surface. Many cases are known in which children born of war grew up in families where they from early childhood felt something was different with them, but did not know why. Often the children were exposed to mobbing, psychical and psychological violence in family, school and neighbourhood. In many countries occupied by the German soldiers during World War II only during the past decades the children fathered by German soldiers and local women have stepped forward and told about their childhood and experiences. Often they did not learn about their real biological background until they were grown-up and then understood why they had been treated so differently to other family members.

The third explanation is closely connected with both previous ones. If children born of war exist in a country or region, but the topic is taboo it is difficult to know the size of this population group. And if the topic is taboo it is difficult to gain knowledge about the real treatment of the child in family, school etc. Usually one may assume that a mother would be the closest person to the child and also act in the interest of the child. When it comes to children born of war, however, this is not always the case, particularly if the child was conceived by rape. However, not even when the child was conceived in a love relationship the mother can or will always act in the interest of the child. Examples from World War II show that the mothers themselves often were exposed to stigmatisation and discrimination as single mothers and/or "enemy sweethearts". This often made it difficult for them to protect their children both against violence within the family, for example, from the stepfather or mobbing in school and neighbourhood. Often the mother left the child in children's homes, gave him/her up for adoption or left him/her with the grandparents in order to move away to a place she was anonymous and could start a new life. The children, however, were left behind in an environment where their biological origin was well known and where they were seen as enemies and treated accordingly (for details see among others Ericsson & Simonsen, 2005b; Mochmann et. al. 2009).

This article will start with a short presentation of children born of war in different wars. Thereafter the Compram methodology will be introduced and then analysed in relation to the problems occurring among the group of children born of war. Finally, the results will be summarised and discussed.

2 Children born of war as a complex societal problem

Mochmann (2008; see also Mochmann & Larsen, 2008) defines four main categories of children born of war. The first category is children of enemy soldiers. In this case children are fathered by foreign soldiers who are clearly defined as enemies in the country or region of location. The second category embeds children of soldiers from occupational forces. These children can be seen as enemies or allies, depending on the view of the local population. The allied forces occupying Germany in the post World War II years, for example, were conceived as saviours by some and as enemies by others. Children of child soldiers are the third category. Female child soldiers are often forced to serve as wives and sex slaves to rebel leaders and children may be born as a consequence of these abuses. The last category includes children fathered by members of peacekeeping forces. Within these categories Mochmann and Larsen (2008:351) suggest that a further distinction may be drawn between children born out of consensual relationships, rape and sexual abuse and prostitution. In situations of war and crisis the borders between sexual abuse, prostitution and consensual relationship are often blurred, however. They thus advice that from the perspective of the child and his/her rights children born of war should not be distinguished based on background of origin before more reliable information and data has been gathered which clarifies similarities and differences between the children (see also Mochmann & Lee, forthcoming).

Although no standardised comparative analysis has yet been carried out, sources so far available indicate that children born of war grow up in a more hostile environment simply due to their biological background, i.e. having a father belonging to the 'enemy' or the 'others', and are thus exposed to stigmatisation and discrimination. These circumstances, in turn, have an impact on their development and even on their right to live. Information on the children and their destinies is rather sketchy as the mothers are often too ashamed or traumatised to address the issue and fear stigmatisation if the child's biological origin is revealed. Over the past decades information from grown up children born of war – particularly from World War II – has become available. The most extensive systematic research has been carried out for the Norwegian children fathered by German soldiers and Norwegian women during World War II. Based on historical documents, qualitative interviews, register data (Olsen, 1998; Borgersrud, 2004; Ellingsen, 2004; Ericsson & Simonsen, 2004; 2005a, 2005b) and quantitative interviews (Mochmann & Larsen, 2008) the life courses of Norwegian children born of war have been analysed. The results indicate that many of these children are born with a stigma of belonging to the enemy and are, among others, often more likely to be exposed to poverty, infanticide, lack of citizenship and lack of education compared to other children. Also many seem to face identity problems due to the lack of information on and knowledge about their biological origin. Literature from other countries such as Denmark (Øland 2001; Mochmann & Larsen, 2005, 2008; Mochmann & Øland, 2009), France (Picaper & Norz, 2004; Virigili, 2009), Greece (Muth, 2008), the Netherlands (Diederichs, 2009), Austria

(Stelz-Marx, 2009), Britain and Germany (Lemke Muniz de Faria, 2002; Lee, 2009) and Vietnam (McKelvey, 1999) prove many similarities, but also differences in the life developments and treatments of this group of children in the respective countries and also differences regarding the treatment these children were given by the military authorities of their fathers. Children born of war as a result of sexual violence in more recent conflicts have been analysed by Carpenter in *Born of war* (Carpenter ed., 2007). This book offers case studies on children born of war and the extension of the 'problem' in conflict zones such as East Timor, Sierra Leone, Northern Uganda, and Bosnia. This research indicates that children born of war in these conflict zones are exposed to many of the same risks as children fathered by occupation soldiers during and after World War II ranging from infanticide to lack of citizenship and social exclusion. Finally, also information available – although very sketchy – on children fathered by members of peacekeeping troops emphasise similarities to other children born of war. Although these troops are often welcomed by the population in the country located, the children may be exposed to discrimination due to a different ethnical look which clearly identifies their father as a soldier. The child is more likely to be exposed to poverty as the mother may have to leave school or work to care for the child as there is no father and no financial support from the father (Eide Andersen, 2008). Children born of war may of course also include children who grow up with both their parents in a normal family, for example, where the mother marries the father and returns with him to his home country as so-called "war bride", in particular if the father was part of an allied troop such as Canadian and US troops in Britain during Second World War (cf. Lee, 2009). Even in countries where the soldiers belong to the occupation army such as in Norway, women married German soldiers and moved to Germany with the children after the war (cf. Aarnes, 2009). To the best of our knowledge this includes a minority of the children born of war, however. Furthermore, these children are not likely to have experienced the same difficulties as those who grew up in their country of birth.[2]

The purpose of this section is to give a brief introduction to emphasise the complexity of this issue. Different dimensions, factors and contexts which are expected to have an impact on the child and his/her development are presented in the Figure 1 below developed by Mochmann (2009).

The four dimensions are: socio-economic, psychological, medical/biological and political/juridical. Factors relevant at the socio-economic dimension include for example poverty, stigma, social exclusion and social deprivation. The psychological dimension includes factors such as identity, lies and taboo. The medical dimension includes factors such as infanticide, trauma, abuse and poor health. The political and juridical dimension covers for example lack of citizenship, exclusion from social services and lack of access to personal informa-

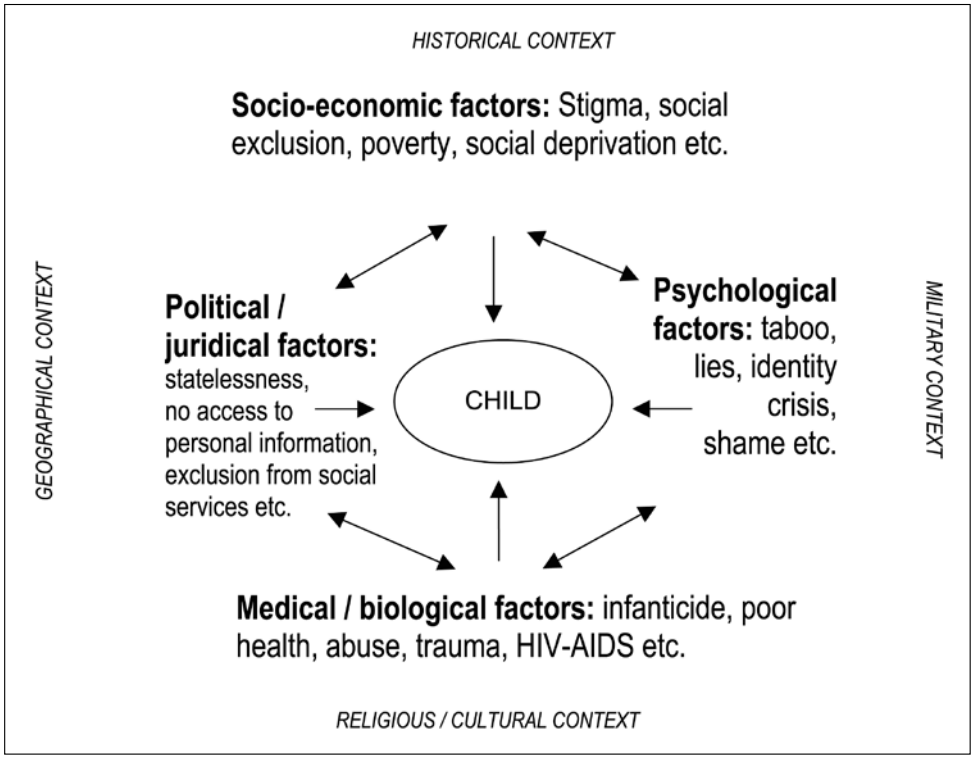

Figure 1: Dimensions, factors and contexts influencing the situation and life development of children born of war (Source: Mochmann 2009)

2 This does not mean that these children and their mothers did not experience difficulties in their new families and countries, such as cultural and language barriers, but this is not the focus of this article.

tion such as information stored in archives or governmental registers. These four dimensions are interrelated and have an impact on the child. For example if a child lacks citizenship he/she may be denied access to social services such as education and child benefit and the taboo surrounding the child's biological identity may cause depression and trauma. How the different factors influence the child is also dependent on the historical, military, geographical and religious/cultural context the child is born into.

All these factors listed in Figure 1 are of course of importance to the development of other groups of children as well. Nevertheless, a major difference is the fact that children born of war are exposed to many of the factors on the different dimensions simultaneously as was shown in the examples given above. Mochmann and Lee (forthcoming) have analysed the human rights of children born of war using the Convention on the Rights of the Child (CRC) (Unicef, 1989) as the starting point of the analysis. In their article children born of war selected from four different wars and conflicts are discussed. They find that although the children differ with respect to background of conception, biological origin, historical and cultural contexts, many children are exposed to the same kind of difficulties and dangers. These range from securing basic rights such as the right to live and survival as well as health, development and education. They argue that there is a tension between protecting the children's right to know and live with their parents on the one hand and the parents', particularly the mother's, right to stay anonymous on the other. Also, the children often face difficulties of integration and are discriminated against, because they are treated as enemies due to their parentage.

Securing the human rights of this group is thus a highly complex societal problem. How the Compram methodology may guide this process will be elaborated after a general introduction to the methodology presented in the next section.

3 The Compram methodology and the handling of complex societal problems

According to DeTombe (2003) complex societal problems are problems where the 'solution' is to be found at the societal level. A problem exists when there is a discrepancy between the actual or (near) future situation and the desired future situation and/or there is a lack of knowledge and/or lack of know-how, and/or lack of relevant data. As for complex interdisciplinary societal problems, the problem is often undefined and the desired situation is not always clear (DeTombe, 1994:58).

DeTombe argues that most large, and important real-life problems are complex societal problems, such as global environmental problems, flooding problems relating to large rivers, extending airports in crowded areas, traffic congestion and water supply problems. The field of complex societal problems also includes unemployment problems, poverty problems, healthcare problems, as well as organisational problems. According to DeTombe complex societal problems are often ill- or multi-defined, hard to analyse and to handle. Knowledge and data are missing or contradictory, the causes of the problem are vague and it is often not clear in which direction the problem is going. Many parties, private and governmental are involved and the problem often has or will have a large impact on (parts of) society.

Complex societal problems themselves are interdisciplinary, involving aspects that are subject of study in several disciplines. The methodology for handling complex societal problems is multi-disciplinary. The scientists working in this field have backgrounds in different disciplines, and use methods derived from their original field combined with methods drawn from other fields. These combined methods are derived from fields like medicine, law, economics, social sciences, mathematics, computer sciences, technology, engineering sciences and operational research. As can be seen from Figure 1 this interdisciplinary approach is essential in the case of children born of war and will be analysed in the next section after a brief introduction of the basic elements and steps of the Compram methodology.

The Compram method is developed by DeTombe in 1994 for handling complex societal problems in a transparent and structured way (1994, 2003). It is based on three basic elements in the management of complex societal problems: knowledge, power and emotion. Knowledge includes having information about the problem. According to DeTombe information is often missing crucial elements and data is often missing or has internal contradictions. The element of power is related to the management of complex societal problems. The management process involves different actors each which dif-

step 1 analysis and description of the problem by a team of neutral content experts (knowledge)
step 2 analysis and description of the problem by different teams of actors (power)
step 3 identification and negotiation of interventions by experts and actors
step 4 anticipation of the societal reactions
step 5 implementation of the interventions
step 6 evaluation of the changes

Figure 2: The six steps of the Compram methodology

ferent power, different views and different goals. Power plays an important role in reaching agreement on the definition of the problem and selecting the interventions. Finally, the third basic element in problem handling is the influence of emotions. Emotions can stimulate or obstruct cooperation between people and between groups.

The Compram methodology includes six steps: knowledge, power, negotiation, societal reaction, implementation and evaluation (Figure 2).

The steps are described in the following:

1. Knowledge: The methodology starts by making an integrated simulation model of the problem by content experts who have knowledge of the different aspects of the problem. Each expert has knowledge of a part of the problem (Figure 3).

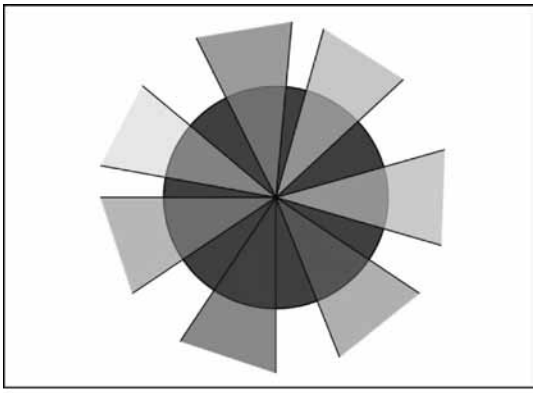

Figure 3: Each expert sees only part of the problem

This is the knowledge step. Questions that should be answered are: What do we know? What do we not know? What are the elements and how are they related? The experts make a simulation model of the elements of the problem supported by a seven-layer model of DeTombe (for details on the 7-layer model see Annex).

2. Power: In step two of the Compram methodology a power analysis is made. The different power groups, the actors, discuss the problem in their own groups and give their perception of the problem, indicate what their desired goals are, on which points they want to cooperate. 3. Negotiation: Then the actors and experts discuss some possibilities for change. Based on the scenarios mutually acceptable interventions are discussed.
4. Societal reaction: The selected interventions are discussed with the public before implementation in step five of the Compram methodology.
5. Implementation: After that interventions are performed in step five.
6. Evaluation: In step six the results and the handling process are evaluated.

In addition to these six steps a phase 0 or so called Quick start workshop is proposed in those cases an emergency situation demands direct handling in order to for example save lives immediately after a Tsunami or earthquake.

DeTombe (2003) argues that problem handling is preferred to problem solving because solving refers to a certain desired goal, and, as the desired goal potentially differs from actor to actor, the end of one problem process might mean a solved problem for one actor and a new problem for another actor. The case of children born of war is a very good example here: Military units may forbid any kind of private contacts and relationships with local women. This does not mean that these do not take place, though, and that children are born out of these relationships. For the military unit the problem is solved by introducing the regulation. For the woman and child the problem gets only worse with this regulation as no paternity proof, alimentation etc. can be requested.

In the next section the basic elements and six steps of the Compram methodology and the roles of different actors will be analysed in the case of children born of war.

4. Analysing children born of war within the framework of the Compram methodology

4.1 The basic elements of Compram: knowledge, power and emotions

The lack of knowledge is a severe problem in the case of children born of war. This group is related to war and post-war times where the situation is usually highly complex per se as many societal problems exist. Children born of war is a typical "blind spot", i.e. it is an area were information would be valuable, but due to the complexity of the problem and due to all the other pressing problems to be solved the area is overlooked. In addition, securing the rights of children fathered by enemies is likely to be low on the priority list in post-conflict situations. Research by Carpenter (2005) among humanitarian organisations in conflict zones shows that these are often not aware that children born of war exist in the country of presence. And in those cases where awareness of such a group existed very little is known about these children. In addition to the blind spots, DeTombe defines the white spots of knowledge (2003:285). These are spots where it is known that information is lacking and that it takes time and money to obtain it. This is the case with many conflicts where the children in the meantime are adults and provide information on their lives. A good example is children born of war and occupation during and after World War II. As presented in section two it is known that German soldiers fathered children all over Europe during this war, even in territories where it was forbidden to them to have relationships with local women such as in Eastern Central Europe and Russia. Yet, only for a few countries research based knowledge is available and in others information has only recently reached the surface. For more than six decades it is likely to have been known that this group of children exists in all occupied countries. At least since the Norwegian children raised their voice in the mid 1980s it is known that these children were often exposed to violations of basic human rights. Still the white spots of knowledge on children born of war during World War II remain. This is also the case with regard to

children born by allied soldiers during and after the Second World War such as Canadian and American troops in Britain, the Netherlands and Germany and Soviet troops in Austria and Germany. These – in the meantime – grown-up children could provide important information for comparative analysis on understanding the impact of different contexts on the treatment of children born during and after World War II. This information could again be helpful in order to understand and evaluate risks children born of war in present day and future conflicts may be exposed to.

The second basic element in Compram is the power related to the management of complex societal problems. The management process involves different actors, each with different power. Actors play an important role in reaching agreement on definition of the problem and in selecting interventions. With regard to children born of war the first challenge lies in the fact that someone must define it as a problem that this group may not have the same rights in the country they are born into as other children have. Even if this is defined, however, it does not automatically imply that this may serve these children. For example, in Norway a government based committee was established in 1945 to discuss the problem of the Norwegian children fathered by German soldiers and how to proceed with them. It was recognised that this group would have a difficult childhood in Norway and several ideas were proposed in order "to solve the problem." Clearly the main concern was not the children's well-being. Among the ideas proposed was offering the children to an Australian delegation who were looking for manpower which was quite absurd as these children were maximum five years old in 1945. There were fears in the Norwegian society that these children would become a German-friendly marching troop in future so authorities were quite interested in finding solutions to send the children out of the country. As they were Norwegian citizens this was not possible unless their mother had married a German soldier and thereby lost their Norwegian citizenship. The women who married a German soldier were sent to Germany with their children. Well-known psychiatrists claimed that the children were less intelligent than other Norwegian children because their mothers had had affairs with German soldiers. The argument was that these mothers were less intelligent because of their behaviour. Therefore the children born by these mothers were also less intelligent. Many children fathered by German soldiers in Norway were therefore put in homes for mentally retarded, treated as such in school etc. (see among others Borgersrud, 2004; Ericsson & Simonsen 2005a, 2008; Mochmann & Larsen, 2008). It was acknowledged that this group of children would have a particularly difficult life. Still, the regulation of child benefit[3] was constructed in such a way that most children of German soldiers did not profit from it. The difficult financial situation already existing because most mothers were single mothers was thereby worsened. Another example is the situation of children fathered by American GI's in post-war Germany.[4] The US authorities refused to take any responsibility for children born by German women and GI's. There were no payments, no citizenships rights and no right to establish paternity. In the case of African-American GI's these children were exposed to similar supposedly "best" solutions by authorities such as juvenile agencies, which sent children away from their families to children homes with the argument that it would be easier for them to be in a closed environment instead of being exposed to public discrimination (see Lemke Muniz de Faria, 2002; Lee, 2009). Unlike in many other wartime or post-war scenarios, in Bosnia, the existence of children born of rape was acknowledged as a challenge for the mothers, for society and it was recognised that the children required protection. This is evident in a 'Fatwa on children born by raped women in Bosnia-Herzegovina' which was issued by the Islamic authority in Bosnia during the civil war. The fatwa ruled that women who had been raped were martyrs of Islam (shahida), and all Muslims were asked to respect and support these women and their children during the healing process. The Islamic leadership urged women and communities to accept and raise war-rape orphans, to integrate them as much as possible into their local communities and secure their social adaptation (see Daniel-Wrabitz, 2007; Weitsman, 2008; Mochmann & Lee, forthcoming).

Finally, the third basic element in problem handling which is emphasised by DeTombe is the influence of emotions which is often underestimated. Emotions can stimulate or obstruct cooperation between people and between groups. Emotions can include anxiety, fear, joy, sympathy and hate and they can be rational or irrational and based on prejudice or discrimination. Emotions play a highly significant role in the problem handling of children born of war and are closely related to the element of power as was shown in the examples above. It is often difficult for (public) authorities, scientists and other actors to hide their emotions when defining the problems, even among allegedly "neutral experts". As these are human beings with their own values and beliefs the questions of objective analyses and measures may be in conflict with their own subjective feelings and interests.

Before continuing with the six steps of Compram the different actors in problem handling and their tasks and positions will be presented. Compram starts when the legitimate problem owner, perhaps supported by one or more content experts, together with a facilitator invites participants to address the problem by forming problem handling teams.

4.2 Problem handling persons: problem owner, facilitator, experts and actors

Different groups of persons can be defined in the handling teams: the legitimate problem owner, the facilitator, the experts and the actors. The problem owner and the facilitator are the first group of persons in the problem handling process. The legitimate problem owner has by law, habit or convention the legitimate task, right or duty to handle the problem. A legitimate problem owner may be a group or institution as

3 Social security payment disbursed to the parents or guardians of children.
4 GI describes members of the U.S. armed forces.

well as an individual. In the case of children born of war the problem owner is usually the state in which the child is born. However, it may also be a national military force or international force who is the problem owner. To which extent the military considers itself responsible for children fathered by members of their forces with local women differs in different conflicts, however. Also in many conflicts it is necessary to differentiate between the situation during and after the conflict. If a military force is occupying a country and their soldiers engage or sexually exploit civilians during this period, the occupying military regime would be the problem owner of the children born out of such relationships. After an occupation or war, however, when the occupying troops withdraw, the problem owner is likely to be the previously occupied state. DeTombe argues that it is important that the problem owner has the right to manage the problem as it increases chances that teams that are invited to discuss the problem will participate and the outcome of the problem handling process has a greater chance of being accepted and implemented. This unclear and changing position regarding who the problem owner for children born of war is may be one of the problems why it has been and still is difficult to address the issue of this group of children in post-conflict settings. In many cases a state has to take over the responsibility as problem owner for children they are not interested in and who very often are also considered as enemies due to their biological origin. It is thus essential that the question of problem ownership is solved and that the problem owner in the different phases of a conflict is redefined should this be necessary. The facilitator is invited by the problem owner to guide the problem handling process. In the case of children born of war facilitators could be organisations such as Unicef, Save the Children, Red Cross and other national and international humanitarian organisations, etc.

The second group of persons in the handling process are the experts. In this phase of the Compram methodology, the process of cooperative problem handling begins by selecting a team of 'neutral' experts by the facilitator in cooperation with the problem owner. The selection of experts depends on the major fields, phenomena, actors that are involved in the problem. If this is not clear at the start of the process the facilitator undertakes in depth interviews with the experts and actors that are known in order to gain more information about the elements that ought to be involved. In the problem handling process two kinds of problem handling teams are involved. The problem handling methodology starts with a team of neutral content experts with knowledge in one of the areas connected with the problem. These experts are more or less neutral towards a certain outcome of the problem handling process. Step one (see Figure 2) of the problem handling process is performed with the experts. In the case of children born of war in present and on-going conflicts in depth interviews with humanitarian workers and medical staff in refugee camps, health centres and similar facilities should take place as early as possible in order to raise the awareness of this particular hidden and marginalised group of children and their mothers. If the interviews indicate that children born of war already exist or are being expected by pregnant women, further experts should join the team such as for example psychologists specialised on trauma related to sexual abuse.

The third and final group of persons in the methodology are teams of actors. Each actor team has its own definition of the problem, its own desires and goals. Actors have a direct interest in the goals and outcomes of the problem handling process as the process affects them directly. The actors can be distinguished into well-organised and unorganised groups where the latter are often forgotten. DeTombe argues that unorganised and less organised groups like children, handicapped and elderly do not have a defender of their interests. She argues that in theory policy makers should take care of the interest of both the well-organised and less-organised groups, but that in practise it is exceptional that the interests of the unorganised groups are taken just as seriously as those of the well-organised groups (DeTombe, 2003:287).

The children are often too small to speak for their own interests and rights. Usually, the mother would act in the interest of the child. However, as elaborated above among children born of war this is not always the case. Often the mother has to protect her own interests which may be opposite to those of the child. The group of children born of war and their mothers are good examples of unorganised groups who have no defender of their interest. As argued previously the mothers are often too traumatised or ashamed to fight for their own rights. Even in present conflicts where women are raped as a military strategy such as in the Democratic Republic of Congo, women are held responsible for being raped and treated as whores in their family and local community. There is a reasonable chance that these women try to hide that they were raped. If they get pregnant this is not always possible and many husbands then leave their wives. Bosnia, where the religious leaders demanded the Muslim community to support women raped by Serb soldiers and children born as a consequence, is an important example of how policy makers may make a difference to unorganised groups. In summary, it may be assumed that the actors have different views on the problem, their own definition and own goals and also often have hidden agendas. In the Compram methodology, the actors and experts join the handling process at an early stage and all participants should agree on the way the problem handling process is guided. In the case of children born of war and their mothers the process may, for example, reveal that the situation and interests of the mothers and children have to be handled separately as a conflict of interest between the two groups may exist.

In the next section the case of children born of war will be discussed for each step of Compram described in section three.

4.3 The six steps of Compram and children born of war

1. Knowledge: As emphasised at the beginning of this article the research area of children born of war is still full of white and blind spots. Still, enough information exists which enables the identification of different dimensions and factors relevant to children born of war. In this process in-depth interviews with the facilitator may indicate additional dimensions and factors of importance to the well-being of children born of war in a particular conflict. In wars these interviews are likely to take place with personnel from humanitarian organisations and health personnel as these experts are usually the first to be in the conflict zone. If interviews confirm that children born of

war already exist or that there are pregnant women and girls who are likely to give birth to such children, measures should be taken to secure the position of the mother or mother-to-be and the child. In this first step, existing knowledge is gathered and potential new analysed.

The facilitator guides the problem handling process of the experts. The problems will become clearer by discussion and making a simulation model of the situation. In the simulation model the relationship between the phenomena which influence each other can be shown. After each round of discussion (step) reports are made in which the result of the problem handling process is described, the selections process of the persons who are invited as well as the discussions points. The content experts will at least include medical staff, psychologists, lawyers, human rights activists and social scientists. This way the handling process is more transparent.

Should the in-depth interviews indicate that the lives of raped women, pregnant women or children of war already born may be endangered phase 0 or the so-called Quick start workshop will be the first step in the process. This step is envisaged in the case of an emergency situation and would include measures such as, in particular, immediate medical and psychological support of the mother and medical support of the child.

2. Power: In step two each actor, guided by the facilitator, discusses the problem in their own group and gives his/her perception of the problem, indicates what the desired goals are, on which points he/she wants to cooperate and on which points not. Groups of persons participating in this process are in this case the countries (problem owner) where the children are born or the military forces if these accept responsibility as problem owners. In any case the military should be included in the process as actors. Other actors are the mothers and children, but also whole families and communities may have a direct interest in the outcome of the process. In many cases whole communities are traumatised such as Northern Uganda where the Lord's Resistance Army (LRA) has terrorised the population since the late 1980s. The reintegration process of abducted former child soldiers is very difficult, particularly for female child soldiers who return with children who were fathered by LRA rebel leaders during captivity. In such cases it seems important that the unorganised groups are represented by authorities representing the interests of these actors, promoting communication and mediation. Such authorities could be religious institutions, respected community leaders, women's groups, local police and NGO's, etc.
3. Negotiation: In this step the views, knowledge and power of the contents experts and different actors are combined. In this phase a representative selection of the actors and experts try to find interventions that are acceptable to the majority of the actors in different areas. It is, for example, asked: Who is responsible for establishing paternity and citizenship? Who is responsible for child benefit? Who is responsible for birth registration and maintenance of biological information? Who is responsible for prosecution if the mother was sexually abused?
4. Societal reaction: In the fourth step the selected interventions are discussed with the public before implementation to try to anticipate the social reactions which the interventions may provoke in order to avoid opposition. In the case of children born of war this step is quite critical. On the one hand a public debate may raise awareness and increase sensitivity and support towards the group of children born of war. On the other hand, singling them out may increase discrimination and stigmatisation. Public resistance may also arise if special attention is paid to this particular population and other war-affected groups feel that children born of war are "positively discriminated". How and to which extent the interventions should be discussed with the public before implementation should be analysed carefully from case to case. In conflicts and post-conflict situations it may also be possible to implement interventions which benefit the group of children born of war without making explicit that the intervention is aimed at this group (and their mothers).

   The two final steps are 5. Implementation and 6. Evaluation. The implementation of the interventions and later on the evaluations of the interventions take time. Both processes require close monitoring over several years in order to be able to evaluate the actual outcome of the intervention. An example may help to illustrate the dilemma. Bosnian children born of rape and their mothers were protected and supported by their religious Muslim community. The religious authorities also decided that in order to avoid discrimination all information which could reveal the real biological identity of the children should be destroyed. The problem is that many children still learn about their real background because there are always relatives, neighbour or schoolmates who know something and share this information. This often results in identity crises and the need to find out more about one's origin. Destroying such files is thus contrary to the interest of the child. To many children of World War II having access to archives and personal files has been tremendously important in order to receive knowledge on "black holes" in their lives and to be able to leave the past behind and look forward.

5 Conclusion and outlook

In this article the group of children born of war was introduced and some of the human rights issues related to this particular group were described and discussed. The situation of these children as "war left-overs" makes difficult an objective treatment and evaluation of the position of this group during conflicts, but in particular in post-conflict settings. The aim of this article was to analyse to which extent the Compram methodology is applicable to this hidden and marginalised population group of the children born of war. In conclusion, the Compram methodology is useful for analysing and handling the complex problems that occur around the children born of war. The methodology makes it possible to analyse the inter-disciplined knowledge by multi-disciplined experts who are able to include and combine the many complicated

factors into the problem handling model. Based on jointly built simulation models interventions can be explored. Handling according to the Compram methodology supports defining and changing a complex societal problem in a sustainable way. In a six step approach experts, actors and policy makers discuss the content of the problem and the possible changes. This framework methodology uses interviewing, the simulation models and scenarios in a cooperative way. The methodology emphasises the exchange of knowledge and understanding by communication among and between the experts, actors and politicians meanwhile keeping emotion in mind. These kinds of complex societal problems include much emotion, both inside and outside the problem handling process. The facilitator is aware of the role emotions play in these kinds of problems and tries to take care of these. The Compram methodology also includes power factors. Each actor has different power, a different definition of the problem and has different desires and goals towards the intervention of the problem. By finding mutually acceptable interventions and looking at the societal reactions, the sustainability of the problem handling process is enlarged. The fifth and sixth step of the methodology considers the implementation and evaluation of the interventions and the effects they have on real life and the process of the problem handling. Reports are made after each step in the methodology which makes it possible to follow the problem handling process. This way the problem handlers can revisit earlier decisions.

In a complex societal problem as that of the children born of war the Compram methodology reveals two important difficulties. The first problem is getting the issue on the agenda. As discussed in this article both shame, taboo, fear of discrimination and stigmatisation may keep mothers and children from coming forward. The Compram methodology may help revealing this issue, thereby providing help to the mothers and children without singling them out. Secondly, finding a legitimate problem owner is a challenge. The problem owner should be legitimate, as neutral as can be, above all parties and should be accepted and respected by all parties. If not, the interventions will not be implemented by the actors or not be accepted by the public. The selection of problem owner and facilitator should be analysed and defined carefully from conflict to conflict. The elaboration of international military guidelines which include the forces' responsibility towards children born of war as well as their mothers would be an important step in this process and would facilitate the definition of the legitimate problem owner. Such an international guideline could be based on the "United Nation Comprehensive Strategy on Assistance and Support to Victims of Sexual Exploitation and Abuse by United Nations Staff and Related Personnel" which was accepted by the UN General Assembly in 2007. This resolution defines all relationships between UN personnel and civilians as sexual abuse and thus ignores the fact that also consensual relationships may occur. Nevertheless, it is a milestone when it comes to recognising the fact that children are born as a consequence of such relationships and that these children and their mothers may need particular support and protection. The impact this resolution has "in real life" still needs to be evaluated, however.

The Compram methodology stimulates creative interventions which supports the sustainability of the intervention. However, even with this sustainable and very transparent methodology handling these kinds of problems will be complicated and difficult: handling a complex societal problem will never be easy.

6 References

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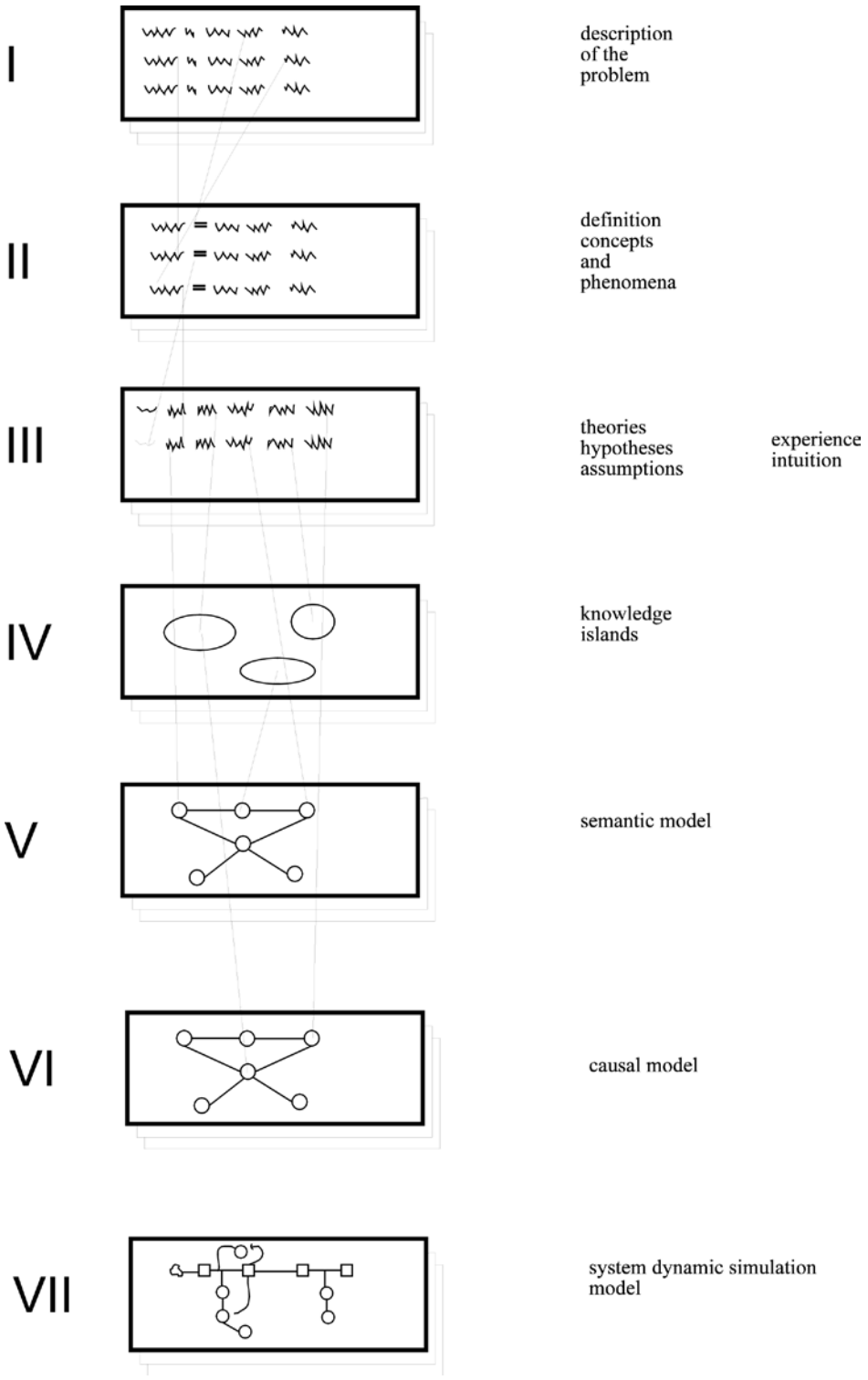
Metodologija COMPRAM in kompleksni družbeni problemi - analiza na primerih otrok rojenih med vojno

Med in po vojnah se rojevajo otroci, kjer je oče član okupatorskih ali mirovnih sil, mati pa je lokalna državljanka. Zagotavljanje človekovih pravic otrok rojenih med vojno je pogosto zelo zapleteno in vključuje raziskovalce in strokovnjake iz različnih področij. Izvedena bo analiza, ali je metodologija Compram, ki se uporablja za reševanje kompleksnih družbenih problemov, primerna za to skupino otrok, ki so prizadeti zaradi vojne. Metodologija Compram je večdisciplinarna in večplastna, vključuje več akterjev in temelji na teoriji družbene kompleksnosti. Metodologija daje smernice za reševanje resničnih kompleksnih družbenih problemov.

Ključne besede: OR v analizi družbenih problemov; raziskava tabujev; metodologija COMPRAM; otroci; vojna

Annex: The seven-layer communication model (DeTombe, 1994)



In Layer I the problem is described in a natural language, in words, each team member understands.

In Layer II the concepts and the phenomena used in the description of the problem in Layer I are defined. In this way the team members are stimulated to operationalise and define the concepts and phenomena they use. This gives other team members the opportunity to learn the concepts of other professions, and it prevents verbalism[i].

In Layer III the relations between the concepts and the phenomena of the problem are described in natural language. These relations can be based on theories, hypotheses, assumptions, experiences or intuition. This indicates the status of

the knowledge. This Layer is related to the description of the problem in Layer I, to the definition of the concepts and the phenomena in Layer I and to Layers IV, V, VI, and VII.

Layer IV shows the knowledge islands. This is a graphic representation of the knowledge of the problem that is needed for handling the problem. The way the knowledge islands are filled indicates the completeness of the knowledge.

In Layer V a semantic model of the problem is made. A semantic model is a graphic representation of the relations between the concepts and the phenomena of the problem described in Layer I.

In Layer VI a graphic representation of the causal relations between the concepts and the phenomena of the problem is shown.

Layer VII contains a system dynamic model of the problem based on the causal model in Layer VI. The system dynamic model contains non-linear connections because of the repetitive interactions between the phenomena and the actors in the model.

Parts of the problem and of the different domain knowledge can be worked out in more detail in sub-sheets of the Layers I to VII. The sub-sheets of one domain are internally connected and are externally connected to the overall problem. It is often necessary to focus on a part of the problem in detail to get a better view, otherwise the models are too large to comprehend. The seven-layer model can be used to support the first sub-cycle of the problem-handling process as well as the second sub-cycle (see DeTombe, 1994) (see Figure 3).

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i Verbalism is using words without knowing what they mean.

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Development of a Web Application for Dynamic Production Scheduling in Small and Medium Enterprises

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This article describes the development of a web-based dynamic job-shop scheduling system for small and medium enterprises. In large enterprises, scheduling is mainly performed with appropriate technology by human experts; many small and medium enterprises lack the resources to implement such a task. The main objective was to develop a cost-effective, efficient solution for job-shop scheduling in small and medium enterprises with an emphasis on accessibility, platform independence and ease of use. For these reasons, we decided to develop a web-based solution with the main emphasis on the development of an intelligent and dynamic user interface. The solution is built upon modular programming principles and enables dynamic scheduling on the basis of artificial intelligence, i.e. genetic algorithms. The solution has been developed as a standalone information system, which allows the management of virtually all scheduling activities through an administration panel. In addition, the solution covers the five main functionalities that completely support the scheduling process, i.e. making an inventory of resources available in the company, using it in the process of production planning, collecting data on production activities, distribution of up-to-date information and insight over events in the system.

Keywords: dynamic job-shop scheduling, genetic algorithms, web application development, web user interface, small and medium enterprises

1 Introduction

An increasing number of companies manufacture their products for each individual customer. Time, together with costs and quality of products, is becoming a crucial factor for a successful business. The time component is especially critical in a make-to-order production facility, where flexibility and reduction of process flow-time determine the rate of success of a company (Buchmeister, Palčič and Pavlinjek, 2008).

The ever-changing business environment is forcing small and medium enterprises (SMEs) to perform management tasks, i.e. production planning, in real-time to meet the delivery dates. Production plants that produce a large number of different specific products cannot hold them all in stock. SMEs also usually have limited production capabilities, which forces them into rash decisions regarding which orders to take from the customers when their production capabilities are exceeded. Such decisions are usually far from optimal, since the quality of their decisions should depend on the synergy effect of their intuition as well as on knowledge and skills, supported by tools that need to be directed into a creative systemic thinking and (co)-operation when solving complex problems (Kramberger and Rosi, 2007). The decision on whether to take another order from the customer is closely correlated to the existing production plan. Hence, if the production capacities are full, or the production plan is difficult to determine, SMEs face severe problems in meeting the delivery dates and in making quality decisions (Choi et al., 2004).

Production processes involve numerous operations with distinct technological ordering, where processing times have to be known as well the workplaces or machines where these operations have to be performed. With increasing numbers of operations and machines, production planners, who mostly use only their experience, intuition and simple techniques, encounter the problem of finding a "good" production schedule in an acceptable amount of time. The obvious consequence is inadequate machine utilization, exceeded project deadlines, increased costs and unsatisfied customers. SMEs are affected by this problem much more than large enterprises, which have the funds and other resources to tackle production-scheduling problems. In SMEs, the production plan is usually dependent on individuals or very small groups of experts that lack the support of modern information technology. Furthermore, customized production requires frequent production rescheduling

as opposed to the production in which large series of products are manufactured. Frequent rescheduling is a consequence of many customers; it obstructs the production of large series, since each customer has its own requirements that the production must adapt to. However, this is the advantage of SMEs, because they produce unique goods with a greater added value.

Stawowy et al. (2007), and Derigs and Jenal (2005) concluded that it is impossible to implement a universal planning system that would cover the wide spectrum of different production branches. Each enterprise needs a tailored version of a planning system, because incorporating all specific requirements of each production branch into a single planning system is not reasonable. Hence, because of the soft and context-dependent aspects of each production branch, to have fully automatized planning processes is not to be expected.

The production planner not only requires production-planning software supported by algorithms, but also all the information available in order to make his decisions easier. Therefore, the user interface has to be intelligent and dynamic, enabling the user to integrate his own ideas and decisions, thus guiding the user through critical situations (Marinho et al., 1999). Lately, there have been an increased number of applications running over the internet. Internet solutions are less expensive, more effective and much easier to maintain than the classic installed software. Web-based applications support different platforms and are easily utilized by different business entities (Tarantilis et al., 2008).

Hence, our goal was to develop a cost effective, modern, robust, accessible and user-friendly web-based application to support production scheduling in SMEs with the use of artificial intelligence (genetic algorithms) as the backbone of the production-scheduling engine. The solution had to be accessible from anywhere, platform independent and easy to use.

2 Production planning and scheduling

Scheduling is a selection process between alternative plans, as well as a determination of the resources and times of each while taking resource constraints into account (Dorn and Slany, 1994). The production-scheduling problem arose in the early 20th century with the emergence of make-to-order production (Jain and Meeran, 1998). Scheduling problems are constantly increasing as development trends force make-to-order manufacturers into quick adaption to customers' demands and competition (Yen and Crow, 1998).

In general, production scheduling is a NP-hard problem that is solvable with robust methods over an infinite or a very long period. A production scheduling method is considered to be good if it reaches a near-optimal solution in a reasonable amount of time (Caseau and Laburthe, 1995).

Muth and Thompson (1963) were among the first who tried to engage the production-scheduling problem. Their model is still used as a quality test of modern scheduling methods. Their goal was to minimize the makespan, but there are many other measures of schedule quality, such as tardiness, etc. There are many methods for solving scheduling problems, such as Branch & Bound, Johnson's algorithm, etc.; however, Davis (1985) was the first to demonstrate the use of genetic algorithms (GAs) to solve scheduling problems. Recently, Kljajić et al. (2001) concluded that the use of GAs contributes to better production scheduling. They used a simulation model and GAs to achieve a better utilization of machines and a decrease of costs associated with it. Consequently, the throughput of the production line increased. Breskvar and Kljajić (2001) showed how to improve scheduling of large series of products with the interconnection of the simulation model and GA to achieve an automatic scheduling process.

In recent times, approaches to reduce high computational runtimes have been emerging. Kofjač and Kljajić (2008) developed a production-scheduling prototype with GA that is supported by a visual simulation model to validate the scheduling algorithm and to incorporate expert knowledge into the production scheduling process. Hence, the search space of GAs is considerably smaller, thus significantly improving the scheduling process runtime.

A key factor for a real-time scheduling process is up-to-date data regarding available manpower, broken machines, cancelled orders etc. It is known that updating data is possible in fully automatized processes. In contrast, keeping data up-to-date in processes where people are involved is a problem. In addition, keeping data up-to-date requires a significant amount of time if this process is not supported by information technology (Ljubič, 2000).

While larger enterprises can invest in adequate technology, such as ERP systems, to support their production processes, numerous SMEs have to cope with a lack of such support. Although ERP systems are complete information technology solutions, they require high maintenance and counselling costs (Na et al., 2003). Furthermore, one of the major drawbacks of ERP systems is their lack of web support, modularity and connectivity with other companies' information technology (Akkermans et al., 2003).

Make-to-order manufacturing cannot depend on standard production processes used for mass production, because make-to-order production usually involves different production activities for each customer's order. Furthermore, it is not reasonable to make a stock of such specific products. Hence, frequent production rescheduling is required to adapt to a new customer's order. In such cases, production activities have to focus on reducing overdue deliveries. Therefore, SMEs need a solution that enables the planning and scheduling of customers' orders while utilizing minimal computational power, which is also supported by web-based applications. Since most SMEs lack resources (manpower, funds, cost effective technology etc.) that would allow them to quickly adapt to customers' demands, there is a great need for a solution that would simplify and speed up the production planning process (Choi et al., 2004).

Several authors have researched the use of web applications in production environments. Qiu et al. (2001) proposed a distributed web multi-user environment for a predefined production plan. Ong et al. (2002) developed a web solution for production assessment in a milling industry, which supports fault detection and energy consumption prediction. Chung and Peng (2004) implemented an object-oriented web technology for management of complex machine and tool selection. Their

web application is a complete solution, adequate for most SMEs with limited funds for investments.

In our case, if we wish to perform scheduling in the proposed web application, we would have to go through the scheduling process shown in Figure 1, which is presented generally. First, we have to define workplaces or machines (CNCs, table saws, etc.). Then we have to define operations (gluing, sawing, etc.) that, together with workplaces, define a job (front side of a drawer, top of the frame, etc.). A set of jobs defines the BOM (the bill of materials; in this case: top drawer, bottom drawer, left and right doors, etc.), while a set of BOMs (wardrobe, table, chair, etc.) defines a project, which represents an order placed by a customer. After all the projects are defined, scheduling can be performed and then evaluated through reporting. Usually, workplaces, operations, jobs and BOMs are defined only once, when the scheduling system is initialized and the data is imported. Afterwards, the scheduling process usually consists only of project definition for each customer, scheduling and report analysis. However, if, for example, a customer requires a cabinet that needs an additional drawer, one may to redefine the BOM and, consequently, the job and some operations. If one needs to update the workplaces, this is usually done when new equipment is bought or when a machine breaks down.

When the schedule has been calculated, it is output via reports. Designated users are allowed to view reports according to their user privileges, e.g. reports for specific workplaces, and perform production activities, such as marking the operation as complete, on a touchscreen in the production hall. In this way, feedback is provided instantly to the production planner so he can make appropriate decisions or maybe even reschedule the production plan to take new or high priority orders into account.

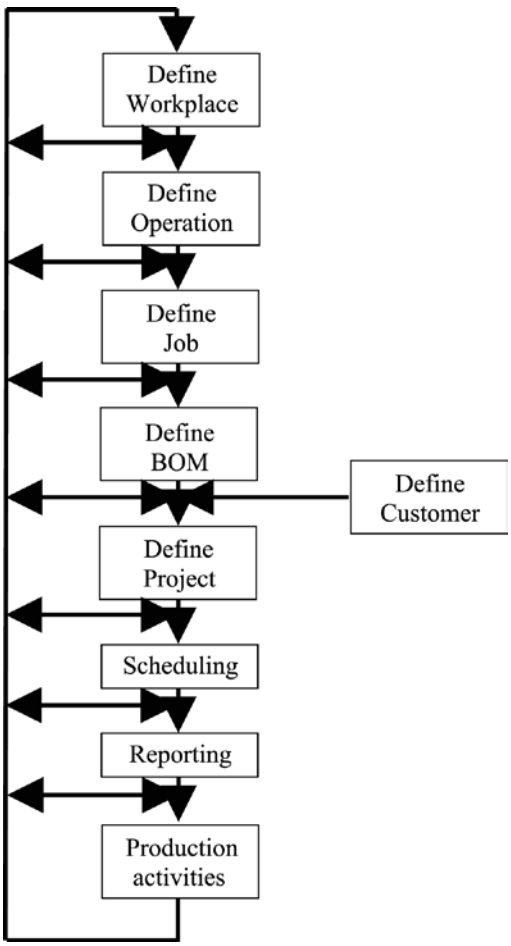

Figure 1: A generalization of a scheduling process.

Development of a production-scheduling algorithm

Scheduling is one of the key processes in production and plays a very important role in a make-to-order manufacturing, which requires great flexibility to meet the constantly changing customer demands. Therefore, the production process needs to be rescheduled frequently to achieve the optimal/near-optimal schedule regarding the criteria function, which in our case is the shortest makespan.

While performing the scheduling process, we face two contradictory criteria: the makespan and the scheduling process runtime. Of course, we want to achieve the lowest makespan possible, but we also have to consider the scheduling process runtime in which the particular makespan is achieved. The scheduling process has to be performed in real-time in order to satisfy the solution feasibility. For example, if production rescheduling is required daily, it would be unacceptable for the scheduling process to take half a day to perform its calculations, regardless of whether it would achieve an optimal schedule. In such a case, we have to consider the near-optimal schedule that was calculated, e.g. in one hour or less.

Therefore, before the scheduling process is started, we have to optimize input parameters. If there are too many input parameters, the scheduling process runtime increases exponentially with the increasing number of input parameters. Furthermore, we also have to consider the simulation timestep Δt, which is an important factor while performing the scheduling process. If we select a Δt that is too short, the simulation runtime would increase greatly, but we would achieve a "fine grained" schedule that would provide much detail. The question is whether we need so much detail. For example, the furniture production does not need a Δt measured in seconds; it is sufficient that the Δt is measured in minutes. In contrast, some other production process, e.g. in the chemical industry, would probably require the Δt measured in seconds or even perhaps in milliseconds.

Job-shop scheduling

We are dealing with make-to-order furniture production, in which furniture is produced in very small series or no series at all. In our case, most of our customers' orders are different. Therefore, production scheduling has to be performed frequently to ensure the optimal/near-optimal production schedule.

The base for scheduling is the bill of materials (BOM) needed to complete a product, e.g. a wardrobe. In this case, a BOM would include a frame, drawers, a door etc. In contrast, for example, a drawer's BOM would include four sides, one bottom, sliders, and so on. Such a BOM can be represented by a tree structure as shown in Figure 2.

One can easily notice that certain parts have to be completed before the assembling of other parts can begin (precedence). Such a tree structure is basically a set of n jobs $J = \{ j_1, j_2, \ldots, j_n \}$ that have to be performed on a given set of m

machines $M = \{ m_1, m_2, \ldots, m_m \}$. A job j_i consists of a set of k operations $O_i = \{ o_{i1}, o_{i2}, \ldots, o_{ik} \}$ that are performed on a subset of machines $H \subseteq M$. An operation o_{ik} is defined by the uninterrupted time period t_{ik} needed to perform this operation and a machine h_{ik} on which the operation is performed. In our case, a job can be repeated on the same machine (recirculation). Furthermore, jobs have to be processed in a given sequence as shown in the example presented by a tree structure in Figure 2. The objective in our case is to produce a product in the shortest time possible, i.e. to minimize the makespan denoted by C_{max} that is defined as the time when the last job leaves the system:

$$\min C_{\max} = \max(C_1, C_2, \ldots C_n), \quad (1)$$

where C_i is the completion time of job j_i.

The problem defined above can be described as the job-shop scheduling (JSS) problem, which is one of the best-known machine scheduling problems. Several techniques to solve complex JSS problems are described in Choi and Yang (2006). In our study, genetic algorithms were used to optimize the production schedule.

Solving job-shop scheduling problem by genetic algorithms

Genetic algorithms (GAs) can be used to search efficiently in a large search space, without explicitly requiring additional information (such as convexity, or availability of derivative information) about the objective function to be optimized (Naso et al., 2007). For this reason, in the previous decade, they have been applied to many (combinatorial) problems, including scheduling.

GA representation of the JSS problem

Recently, different GA representations for job-shop scheduling problems have been proposed, e.g. operation-based, job-based, machine-based, etc. (Gen and Cheng, 1997). In our research, we have used an operation-based representation that encodes a schedule as a sequence of operations, with each gene standing for one operation. All operations for a job are given with the same symbol and are then interpreted accordingly to the order of occurrence in the sequence for a given chromosome, as proposed by Gen, Tsujimura and Kubota (Gen and Cheng, 1997).

Consider the three-job four-machine problem given in Table 1. Jobs j_1 and j_2 have to be completed before the processing of job j_3 takes place. Hence, a chromosome is divided into sections (see Figure 3), and crossover and mutation can be performed only inside a section.

Table 1. An example of a three-job four-machine problem – operation machine sequence for each job.

	Operations			
Job	1	2	3	4
j1	m1	m3	-	-
j2	m1	m3	m4	-
j3	m1	m2	m1	m4

2	2	1	1	2	3	3	3	3

Section 1 | Section 2

Figure 3: A chromosome division into sections regarding the job precedence constraint.

Suppose a chromosome is given as [2 2 1 1 2 3 3 3], where 1 stands for job j_1, 2 for job j_2, and 3 for job j_3. Job j_1 has two operations (there are two 1's in the chromosome), job j_2 has three operations, and job j_3 has four operations. For example, the first 2 corresponds to the first operation of job j_2 (which will be processed on machine m_1), the second 2 corresponds to the second operation of job j_2 (which will be processed on machine m_3), and the third 2 corresponds to the third operation of job j_2 (which will be processed on machine m_2) as shown in Figure 4 (respectively for jobs j_1 and j_3). Note that Operations 1 and 3 of job j_3 are performed on machine m_1 (recirculation).

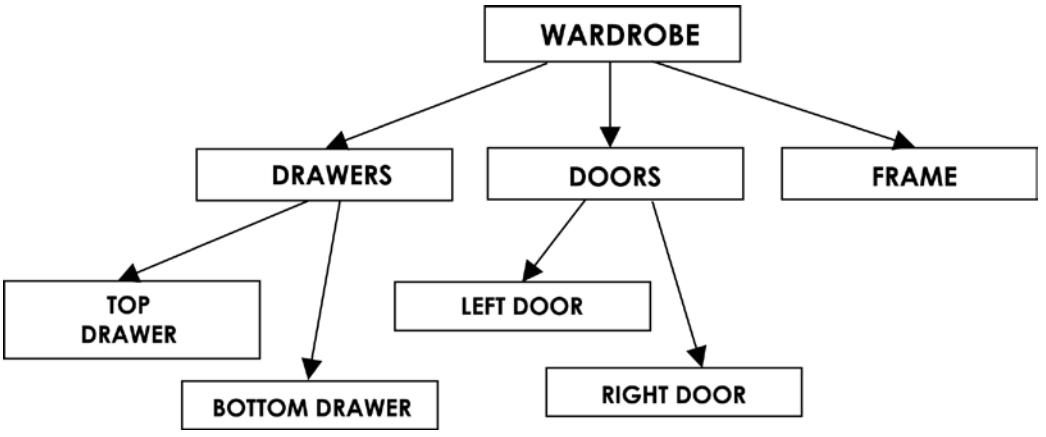

Figure 2: A part of a wardrobe BOM represented by a tree structure.

Initial population

The initial population of chromosomes was generated in two ways: randomly and by mirroring. Random generation is a commonly used technique for providing an initial population of chromosomes in the absence of *a priori* information about the solution. In the first step, *N* equal individuals are created as described earlier. Next, the genes in each section are moved to a random position inside the same section, thus providing a random schedule.

Because random generation does not necessarily provide a good initial population, the mirroring of initial population was used (Kofjač and Kljajić, 2008). Kofjač and Kljajić proved that it is possible to improve our chances of starting with a fitter solution by simultaneously checking the mirrored solution. By doing this, the fitter one (random or mirrored) can be chosen as an initial solution. Therefore, starting with the closer of the two guesses (as judged by its fitness) has the potential to accelerate convergence.

Mirroring is performed as follows: in the first step, an initial population of size *N* is generated randomly. Next, each individual in a randomly generated population is mirrored, i.e. each section inside an individual is mirrored, thus obtaining another *N* individuals. Individuals of both populations are then grouped and ranked according to the fitness function. Finally, the best *N*-ranked individuals are taken as the initial population. By utilizing mirrored points, we can obtain fitter initial population even when there is no *a priori* knowledge about the solution(s).

Chromosome:	2	2	1	1	2	3	3	3	3
Machine:			1	2					

(a)

Chromosome:	2	2	1	1	2	3	3	3	3
Machine:	1	2			4				

(b)

Chromosome:	2	2	1	1	2	3	3	3	3
Machine:						1	2	1	4

(c)

Figure 4: Operations of jobs and corresponding machines: (a) for job j1, (b) for job j2 and (c) for job j3.

Selection

Several selection methods to choose chromosomes for the next generation were tested: roulette selection (see Gen and Cheng, 1997), fitness rank distribution (Reeves, 1995), and Fibonacci selection (Bernik, 2001). Also, the elite selection is performed to preserve the best individuals.

The roulette selection is a fundamental selection method used in GA. In roulette selection, the fitness function assigns a fitness value to chromosomes. This fitness value is used to associate a probability of selection with each individual chromosome. If f_i is the fitness of an individual i in the population, its probability of being selected is:

$$p_i = \frac{f_i}{\sum_{j=1}^{N} f_j} \tag{2}$$

where N is the number of individuals in the population. While candidate solutions with a higher fitness will be less likely to be eliminated, there is still a chance that they may be.

The fitness rank distribution (FRD) was introduced by Reeves (1995). It selects parents according to the following probability distribution:

$$p_i = \frac{2i}{M(M+1)} \tag{3}$$

where i refers to the i-th chromosome in descending order of makespan and M refers to the fittest one. This implies that the median value has a chance of $1/M$ of being selected, while the fittest one (the M-th chromosome) has a chance of $2/(M+1)$, roughly twice the median.

The Fibonacci selection was first introduced by Bernik (2001) and uses a Fibonacci sequence (0, 1, 1, 2, 3, 5, 8, etc.) to select individuals. The Fibonacci sequence is defined as follows:

$$F_n = \begin{cases} 0 & \text{if n =0;} \\ 1 & \text{if n =1;} \\ F_{n-1} + F_{n-2} & \text{if n >1.} \end{cases} \tag{4}$$

Individuals from a population are selected according to the places defined by Fibonacci numbers. By applying this method, the fittest individuals are selected more often than the less fit ones. Hence, the variety of population is maintained and the survival of the fittest concept is being applied, while the GA converges faster towards the solution.

Crossover

To produce a new generation of chromosomes, a crossover is applied with a given probability (p_C). The one-cut-point crossover (CUT) and linear order crossover (LOX) were tested. Note that crossover can be applied only inside a section (e.g. Section 1).

Consider two parents and two child chromosomes for CUT crossover as shown in Figure 5. In the first step, genes [2 2] are copied from Parent 1 to Child 1 up to the crossover point. Respectively, genes [2 1] are copied from Parent 2 to Child 2. Child 1 is missing the genes [1 1 2] and Child 2 is missing the genes [2 1 2]. The missing genes gap is filled in Step 2. To produce a feasible schedule, the gap in each child must be filled with the missing genes by taking each legitimate gene from the other parent in order. For example, a gap in Child 1 is filled with the sequence [1 2 1], while the gap in Child 2 is filled with the sequence [2 2 1]. Note that the number of 1's and 2's in both "fill" sequences is equal to the one in the missing genes sequence; only the order in which 1's and 2's appear is different.

Mutation

After applying crossover, two types of mutation were tested: exchange (EX) and shift (SH) mutation. Mutations are applied to a child with a varying probability p_m (see Reeves, 1995). The mutation rate is calculated as:

$$p_m = 1 - \frac{fit_{best}}{fit_{child}} \quad (5)$$

where fit_{best} represents the fitness function value of the chromosome that has yielded the best result and fit_{child} the fitness function value of the child that requires mutation. The chromosome with the fitness function value closer to the fit_{best} would have a lower p_m than the one with the fitness function value closer to the worst value.

The exchange mutation is performed by swapping the places of genes (chosen randomly) to produce a feasible solution (see Figure 7). The shift mutation performs a shift of one gene (chosen randomly) to the right or left for a random number of places (see Figure 8). Again, the mutation can only be performed inside a section.

Parent 1:	2	2	1	1	2	3	3	3	3
Parent 2:	2	1	2	1	2	3	3	3	3
Step 1:									
Child 1:	2	2	X	X	X	3	3	3	3
Child 2:	2	1	X	X	X	3	3	3	3
Step 2:									
Child 1:	2	2	1	2	1	3	3	3	3
Child 2:	2	1	2	2	1	3	3	3	3

Figure 5: An example of the CUT crossover in Section 1.

Step 1:									
Parent 1:	2	2	1	1	2	3	3	3	3
Parent 2:	2	1	2	1	2	3	3	3	3
Step 2:									
Parent 1:	X	2	X	1	2	3	3	3	3
Parent 2:	2	X	2	X	2	3	3	3	3
Step 3:									
Parent 1:	2	1	X	X	2	3	3	3	3
Parent 2:	2	2	X	X	2	3	3	3	3
Step 4:									
Child 1:	2	1	2	1	2	3	3	3	3
Child 2:	2	2	1	1	2	3	3	3	3

Figure 6: An example of the LOX in Section 1.

Parent:	2	2	1	1	2	3	3	3	3
Child:	1	2	1	2	2	3	3	3	3

Figure 7: An example of EX mutation in Section 1.

Parent:	2	2	1	1	2	3	3	3	3
Child:	2	1	1	2	2	3	3	3	3

Figure 8: An example of SH mutation in Section 1.

Population size

The effects of setting the parameters of evolutionary algorithms (EA) has been the subject of extensive research by the EA community; recently there has been much attention paid to self-calibrating EAs that can adjust their parameters on-the fly (see e.g., (Eiben et al., 1999) and (Eiben and Smith, 2003) for review). The most attention and most publications have been devoted to the adjustment of parameters of variation operators. Adjusting population size is much less popular, even though there are biological and experimental arguments to suggest that this would be rewarding. Looking at it technically, population size is the most flexible parameter in natural systems: It can be adjusted much more easily than, for instance, the mutation rate. In evolutionary computing, however, population size is traditionally a rigid parameter (Eiben et al., 2004). The new population resizing mechanism used here was introduced by Eiben et al. (2004) and is based on improvements of the best fitness in the population. With fitness improvement, the algorithm becomes more biased towards exploration; increasing the population size, short term lack of improvement makes the population smaller, but stagnation over a longer period causes populations to grow again. Technically, this approach applies three kinds of changes in the population size:

If the best fitness in the population increases, the population size is increased proportionally to the improvement and the number of evaluations left until the maximum allowed. The formula used for calculating the growth rate GR_1 for is:

$$GR_1 = incFact \cdot (maxEvalNum - currEvalNu\,m) \cdot \cdot \frac{maxFitness_{new} - maxFitness_{old}}{initMaxFit\ ness} \quad (6)$$

where *incFact* is an external parameter from the interval (0,1), *maxEvalNum* and *currEvalNum* denote the given maximum number of fitness evaluations and the current evaluation number. *maxFitnessnew*, $maxFitness_{old}$ and *initMaxFitness* are the best fitness values in the current generation, the same in the preceding generation and the best fitness value in the initial population. (Note that we assume the existence of *maxEvalNum*, which is very often present. In case it is not given, a very large number can be used instead.)

The population size is increased by a factor GR_2 if there is no improvement during the last V number of evaluations. In principle, the mechanism to increase the population size in this step can be defined independently from the previous one; in fact, we use the same growth rate, i.e. GR_1.

If neither 1. nor 2. was executed, then the population size is decreased. For the decrease rate (DR), a small percentage of the current population size is used, e.g. (1-5%).

In addition, we added a war or disease process in the population-growth process, similar to the one introduced by Shi et al. (Reeves, 1995). It is known that the natural environment

does carry some capacity that cannot be exceeded; hence, we shrunk the population to its initial size after the population exceeded a user-defined maximum population size.

Results

The experiment was performed on a computer with Intel Core2 Quad 2.4GHz processor and 4GB RAM. The GA optimization algorithm was implemented with MS Visual Studio 2008 in C# technology.

Twenty-one were machines needed to perform JSS. Three JSSP configurations were tested during the experiment:

1. BOM1 – 96 jobs divided into four sections with a chromosome length of 447 genes.
2. BOM2 – 101 jobs divided into four sections with a chromosome length of 558 genes.
3. BOM12 – a combination of BOM1 and BOM2.

Most jobs in BOM1 and BOM2 require six operations, while the minimum is one and maximum is 13 operations per job. Jobs with no operations are considered assembly jobs that do not require any operation to be performed but are needed to satisfy the precedence constraint. Approximately 20% of jobs do not require recirculation.

Four different GA configurations were tested; each GA configuration utilizes different GA methods as shown below:

1. No mirroring applied, roulette selection utilized, a population of 50 individuals, CUT and EX methods applied, CUT method applied in 80% of cases.
2. Mirroring applied, roulette selection utilized, a population of 100 individuals, CUT, LOX and EX methods applied. In the crossover process, the CUT method was applied in 60% of cases and LOX method in 40% of cases.
3. Mirroring applied, FRD selection utilized, a population of 100 individuals, CUT, LOX, EX and SH methods applied. In the crossover process, the CUT method was applied in 60% of cases and LOX method in 40% of cases.
4. Mirroring applied, FRD selection utilized, variable population with an initial value of 50 individuals, CUT, LOX, EX and SH methods applied. In the crossover process, the CUT method was applied in 60% of cases and LOX method in 40% of cases.

Each JSSP configuration was run 10 times for each GA configuration, and average makespan and runtime were calculated. Then for each GA configuration, the results of each JSSP configuration were summed (BOM1+BOM2+BOM12) to yield the makespan and runtime for each GA configuration.

The results of the production scheduling simulation are presented in Figure 9, showing makespan progress through the research by utilizing different GA methods. Four different GA configurations are presented and compared, regarding makespan (solid line) and runtime (dashed line).

The first configuration was our starting point. Obviously, it yielded the worst makespan (3995 min) of all GA configurations and the shortest simulation runtime (131s), due to the smaller population size and the utilization of fewer and simpler GA methods. The second configuration, including mirroring of initial population, increase of population to 100 individuals, LOX and EX method, yielded a far better makespan (3489 min) and a longer runtime (165s) due to increased population size and application of more GA methods. The third configuration, reverting from roulette to FRD selection and including the SH method, yielded another significant improvement in makespan (3030 min) while greatly increasing the runtime to 339s, due to the more complex selection method and an application of another GA method. The fourth configuration, reverting from a fixed population size to variable, yielded a slight improvement in makespan (3026 min)

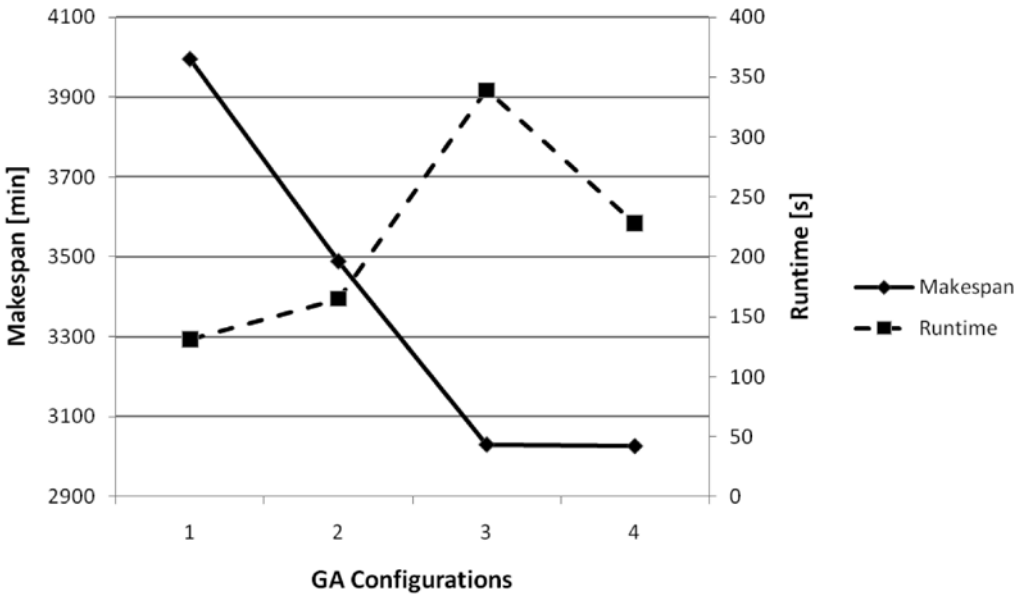

Figure 9: A comparison of makespan and runtime for different GA configurations.

while the runtime (228s) significantly improved over the third configuration.

One can notice a significant improvement in makespan from the first to the fourth configuration, with a decrease of 969 min or 24.3%. In contrast, the runtime increased by 97s or 74%. However, the makespan improvement more than compensates for the runtime increase.

3 Web application development

A web application is an application that is accessed via a web browser over a network such as the internet or an intranet. Web applications are popular due to the ubiquity of web browsers, and the convenience of using a web browser as a client. The ability to update and maintain web applications without distributing and installing software on potentially thousands of client computers is a key reason for their popularity, as is the inherent support for cross-platform compatibility. The drawbacks are the inaccessibility of a web application if the internet connection is broken and vulnerability to threats emerging on the internet. Web applications are based on a client-server principle, in which the client-server characteristic describes the relationship of cooperating programs in an application. The server component provides a function or service to one or many clients, who initiate requests for such services.

Our web solution is based on the web application model shown in Figure 10. The client sends HTTP requests to the Apache web server through the user interface. The Apache server interconnects with MySQL Database to retrieve or store the data, and with a scheduling engine to perform the scheduling process. The processed data is then sent back to the user and displayed on the user interface.

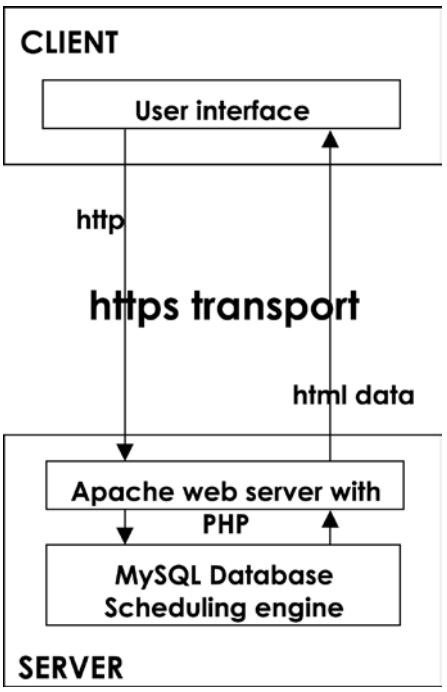

Figure 10: Web application model in our case

Together with a secure web server, reliable database, and an effective scheduling engine, the user interface is a key to application usability. The user interface should include six functional areas: data entry, data display, sequence control, user guidance, data transmission, and data protection (Smith and Mosier, 1984). The system's user interface was developed with the intention of decreasing the cognitive load by using a well-structured presentation of strategic information, which can greatly improve the utilization of such a system (Schuurman et al., 2008). The user interface will be effective if all user actions are performed with minimal effort, if all users are satisfied with it and have a feeling that it offers support in what they do (Desemo et al., 2008). Hence, the user interface is one of the key factors of a successful information system, and web applications are based on a functional user-interface. An example of our user interface is shown in Figure 11.

The division of system functionality into modules enables understanding of a complex system, in which a vast number of variables are hard to control. Complex problems can be solved efficiently if they are divided into controllable parts. This also holds for software and its modules (Solina, 1997). Our web solution consists of seven main modules (Knaflič, 2009):

1. User management (adding new users, granting privileges, etc.),
2. News management (news categories, adding new news, etc.),
3. Resource management (workplaces, operations, jobs, etc.),
4. Customer management (adding new customers, modifying existing ones, etc.),
5. Project management (adding new projects, modifying existing ones, etc.)
6. Planning module (setting planning attributes, performing scheduling, etc.),
7. Reporting module (generating reports on the basis of production planning module).

Modules are then grouped into three tiers regarding user privileges (Figure 12):

1. General – visible to all users, providing basic news and company information,
2. Registered users – visible to those whose functionality depends on user privileges, providing detailed information, reporting, and enabling production-related activities with touchscreens in the production hall,
3. Administrative – visible only to administrators, where user, resources, news, customers, and projects management is available, as well as production planning.

With the web application design described above, we have successfully developed a system that covers all the main functionalities that completely support the dynamic production scheduling process.

4 Conclusion

Production scheduling systems are a specific form of decision support system. The market is full of commercial tools that require major investment if they are to be implemented in production systems. Furthermore, such tools usually impose

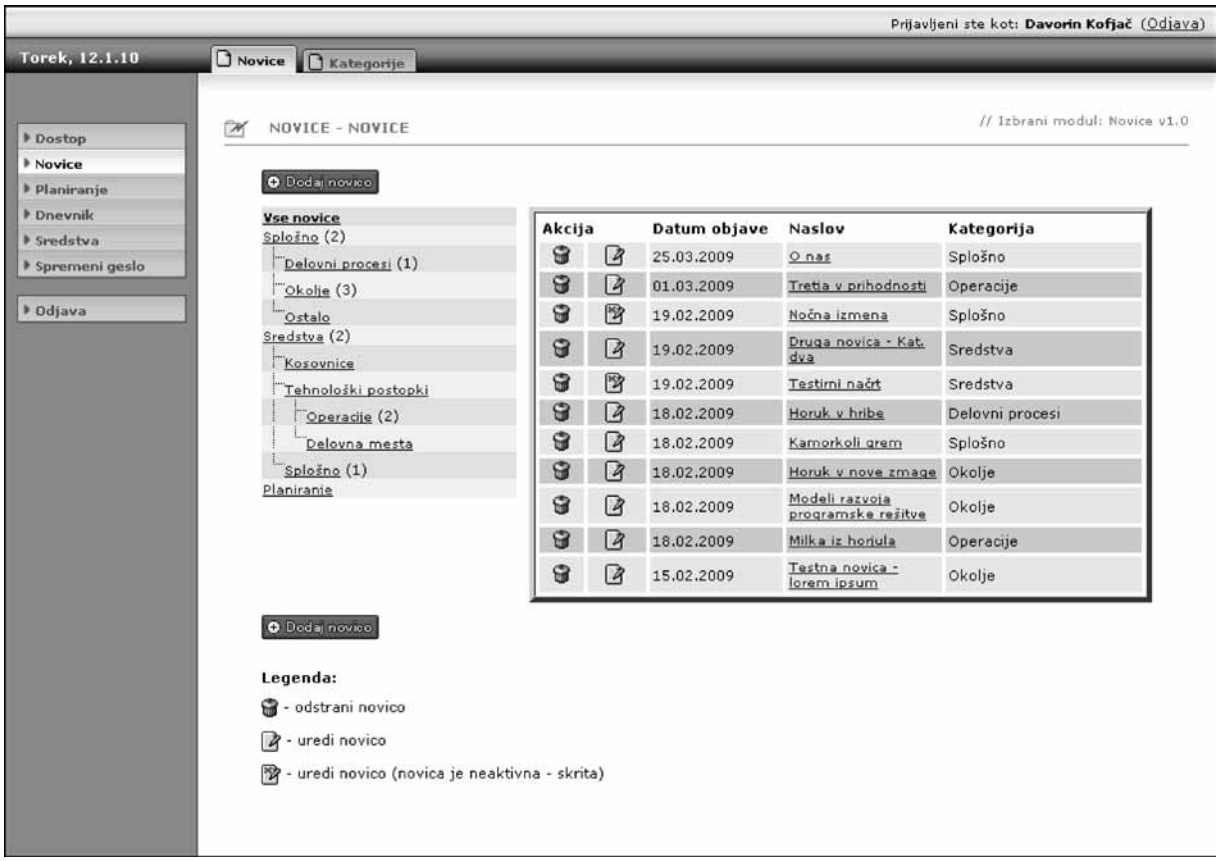

Figure 11: An example of News management in the administration tier

high costs for support and maintenance. Small and medium enterprises (SMEs) do not have the funds necessary to implement such tools, but have a great need for them, because they must cope with limited inventory capacity, limited workforce and other resources, highly flexible production and so on. Therefore, web solutions that are easy to implement, platform independent, accessible from anywhere, and, most importantly, have low maintenance costs are most appropriate for SMEs.

Our web solution to support dynamic production scheduling was developed with open source technologies, such as PHP and MySQL; only the powerful computational scheduling engine was implemented with a commercial product, Microsoft Visual Studio. The web solution supports resources management, such as users, workforce, jobs etc., production scheduling (supported by genetic algorithms), reporting and real-time activities in the production process, such as marking specific operations as complete on a touchscreen in the production hall. The web solution is built in a modular way, with an intuitive and user-friendly graphical user interface to support man-machine interaction.

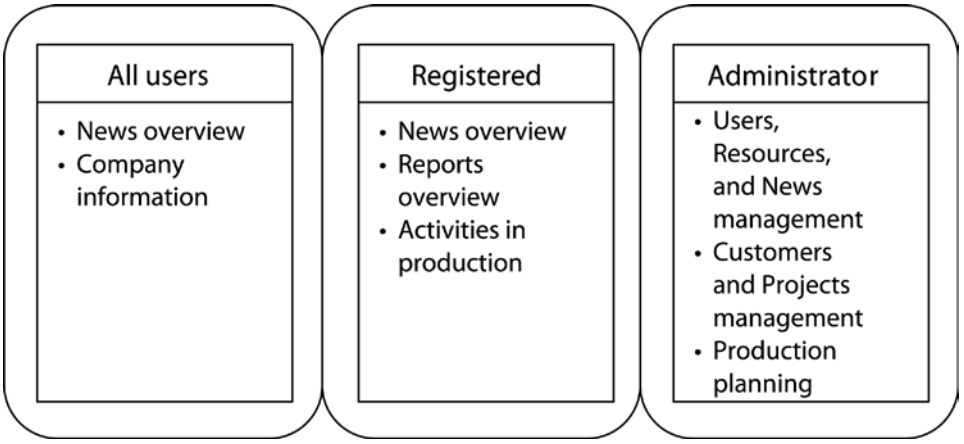

Figure 12: Three tier web application configuration regarding user privileges

In our case, production scheduling is based on genetic algorithms. We have proven that genetic algorithms (GAs) perform well in our case of a make-to-order production process, which can be described as a job-shop process. GAs are very effective in solving job-shop scheduling problems because they are able to explore a vast search space with the goal of finding an optimal/near optimal schedule. We have shown that only by applying different GA methods can one achieve a 25% lower makespan that can be performed in a reasonable amount of time, because real-time scheduling is required in such a dynamic and flexible production system.

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Razvoj spletne aplikacije za dinamično razporejanje proizvodnje v malih in srednje velikih podjetjih

Prispevek obravnava razvoj spletne aplikacije za potrebe dinamičnega razporejanja proizvodnje v malih in srednje velikih podjetjih. Medtem ko večja podjetja lahko investirajo v ljudi in ustrezno tehnologijo, ki podpira aktivnosti razporejanja, številna mala in srednja podjetja trpijo prav zaradi pomanjkanja podpore pri upravljanju le-teh. Glavni cilj je bil razvoj stroškovno ugodne, učinkovite rešitve za potrebe razporejanja proizvodnje v malih in srednjih podjetjih s poudarkom na dostopnosti, neodvisnosti od platform in enostavnosti uporabe. Zaradi tega smo se odločili za razvoj spletne rešitve, pri kateri je bil glavni poudarek na razvoju inteligentnega in dinamičnega uporabniškega vmesnika. Rešitev je zgrajena modularno in omogoča dinamično razporejanje naročil v proizvodnjo na podlagi metode umetne inteligence - genetskih algoritmov. Rešitev je razvita kot samostojen informacijski sistem, ki preko administracijskega vmesnika omogoča upravljanje vseh aktivnosti razporejanja. Tako lahko posameznim uporabniškim skupinam določamo ustrezne dostopne pravice in s tem uporabnikom omogočamo izvajanje posameznih aktivnosti. Poleg tega je v nalogi zajetih še pet glavnih funkcionalnosti, ki podpirajo dejavnosti razporejanja. Tako rešitev omogoča popisovanje sredstev s katerimi podjetje razpolaga, uporabo le-teh v procesu planiranja proizvodnje, zbiranje podatkov o proizvodnih aktivnostih, ažurno razpečevanje informacij in izvajanje nadzora nad dogajanjem v sistemu.

Ključne besede: dinamično razporejanje proizvodnje, genetski algoritmi, razvoj spletne rešitve, spletni uporabniški vmesnik, mala in srednje velika podjetja

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Simulated Decision Learning in a Multiactor Setting

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The idea of decision analysis – and subsequent learning from the outcomes – is old within Operational Research. Here this approach to continuous improvement of decision outcomes is put one step further within the area of crisis and disaster management. This is done by introducing multiactors making simultaneous decisions with just partial information about each other. Further, decision outcomes are achieved from a simulation model rather than from the real object system.

Keywords: Multi Layered Systems, Anticipation, Retardation, Learning, Simulation.

1 Introduction

As manifested in the European FP7 research program, Security has lately become a main issue in European Research and Technical Development[1] (RTD). This broad area includes, among many other topics, research on simulation, planning, and training tools for management of crisis and complex emergencies. The rationale for that focus may be found in current research. In short, those recent research results indicate that the outcome of an emergency situation to a large extent is due to the preparations and trainings done before the crisis or disaster outbreak (Bolin and Hart, 2007). Those current research insights, however, is still just to a tiny bit transformed into operational training tools.

Hence, this paper will demonstrate and discuss the design of the netAgora crisis simulation and training environment. It is a solution both meeting the requirements of a recent FP7[2] call and building on current research results.

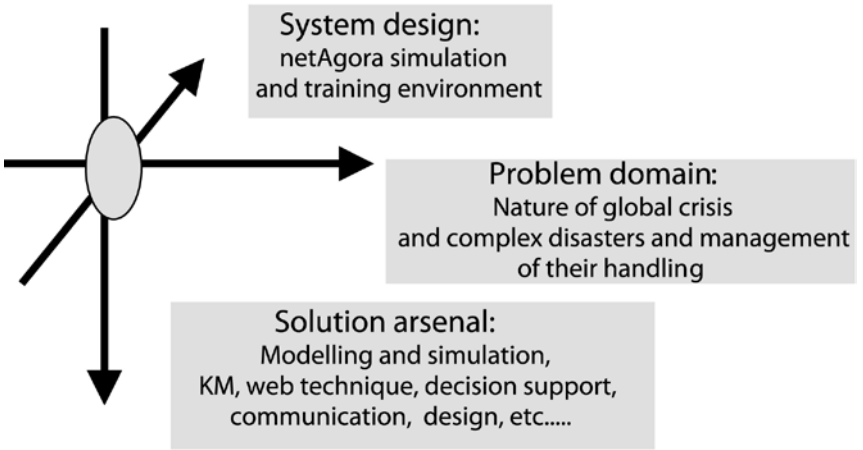

Figure 1. Integration of problem domain insights and solution arsenal competencies.

1 http://cordis.europa.eu/fp7/dc/index.cfm
2 Call identifier: FP7-SEC-2009-1, Date of publication: 3 September 2008

The purpose of this paper, hence, being to increase the understanding of proper facilities for crisis and disaster training and preparation. The solution put forward here applies systems thinking and a multi modal system design methodology in order to solve a practical operational planning problem. This approach will integrate research insights from both social and engineering (technological) sciences.

2 Research approach

In the quest for the netAgora research objective, systems science and multi methodology will constitute the epistemological base. From that base an experimental and prototyping process will be applied toward the project goal. The meaning of this approach will in some detail be discussed with help of Figure 1.

In Figure 1 the horizontal, problem domain, axis is the primary, steering or predominant one. It points toward the part of the real world that ought to changed by netAgora's deliberate actions. In the actual case, this mean training and preparation facilities for global crisis and complex disaster situations.

Whatever method and technique that may be used, however, it is just the impact in the problem domain that will be the measure of success or failure. Hence starting on the horizontal axis, a broad survey of current research results from the social sciences will be performed. That will give an understanding of netAgora's part of the problem domain and its specific requirements. Those identified requirements will then work as the target for the rest of the netAgora process.

Coming to the vertical axis, i.e. the solution arsenal, here are all the methods, techniques, and tools that can be useful in providing the best possible solution for the problem domain items in focus. Here netAgora identify its task as an application of Operational Research (OR) with its specific challenges and problems (Holmberg, 2001). However, as Keys (1991) has identified close and obvious relations between OR and systemics, it is found that the solution mainly ought to be created with help of systems thinking and systemic methodologies. Leleur (2005) has on this point demonstrated how the highly theoretical thinking of Habermas and Luhmann can be applied in a pragmatic way in working with complex inter national projects.

As the problem domain in focus is highly complex and exposes all aspects of human life netAgora chooses the much inclusive Living Systems Theory (Miller, 1978) as a general framework. Albeit it is a representative for the somewhat outdated Functionalist Systems Approach Holmberg (2008) has demonstrated that Living Systems Theory has a great potential for further development and symbiotic combinations with other methods and theories. This is fully in line with the Multi Methodology approach advocated by Mingers and Gill (1997) and others.

Our working methodology will closely follow Idealized Design according to Ackoff et al (2006). This well proven design methodology has already been used with good results on several occasions (Holmberg, 2001). Other design input comes from Warfield's (1990) Generic Design and Banathy's (1996) third generation's Social Systems Design.

For the technical tools, at last, netAgora will use web services not only for providing information but even more for encouraging participation and empowerment (Nyström, 2006). Implementation of codesign, according to the vision of third generation design (Banathy, 1996), may also be within reach with help of web technology (Löfstedt, 2008).

A simulation technique, which is simple and straightforward to distribute over intranet to ordinary users without any specific simulation skills, have been demonstrated by Dubois and Holmberg (2008) and will be applied also here. Geographical or spatial information, which is crucial in this type of applications, will be handled with a fuzzy approach (Asproth et al., 2006).

Hence, by integrating all that have been discussed so far in a design process, the solution will emerge along the third and last axis in Figure 1. This result will be the design for the netAgora simulation and training environment.

Project control

With the epistemological and methodological principles established the project has to involve and enhance cooperation between several European universities together with major organisations and industry firms from the specific area of emergency and disaster management. With this broad EU partner base the project is divided into seven distinct work packages and with three to five partners cooperating in each of them.

NetAgora, as seen in Figure 2, departures from two launching points in its first work package (WP1). Those are first the needs, wishes, and requirements of netAgora's future users. The second is the existing stock of open source tools and development environments. With this platform established it is the responsibility of WP2 – WP4 to design and construct both a set of test scenarios and the netAgora environment with its disaster simulator and other training tools. With a first version of netAgora environment up and running, verification and improvements will be done in WP5 – WP6. Here true users from different user categories will run the disaster simulator and environment with the different test scenarios. Tho evaluation results from those tests will finally be used in correcting faults and in improving the tools.

During the predicted project time of 40 months great effort should be put into management and coordination of the project (WP0). As the project should involve researchers and developers from both social and technological sciences together with a great number of normal users from different cultural milieus, this complex WP will require both finesse and high attention.

Dissemination (WP7), at last, is the interface towards European security actors at large. Through this activity the project results are put to the benefit of European citizens and European firms working within the security sector. The distribution of those phases or work packages is shown in Figure 2.

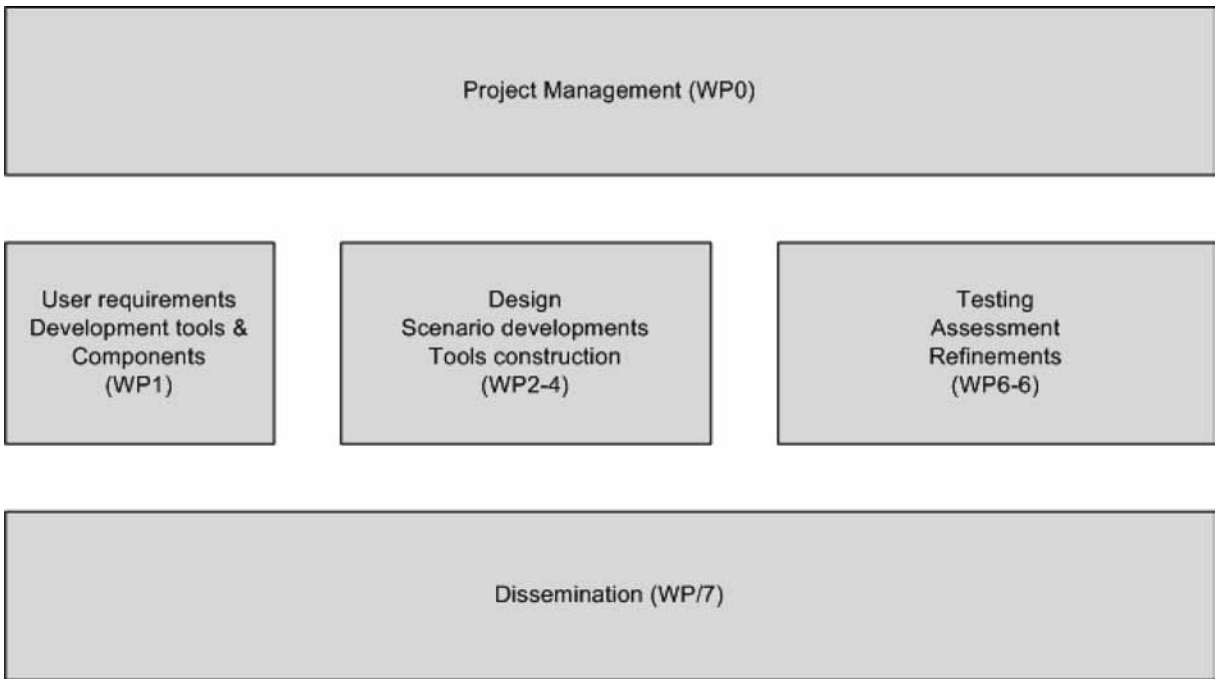

Figure 2: Main blocks of the netAgora project.

3 Current research and steps beyond

The systematic social science study of disasters has only been present for half a century and social science knowledge for dealing with disasters is hence a rather recent phenomenon (Quarantelli, 1988; 2000). Here Boin and 't Hart (2007) claim that a mix of perspectives is needed to understand the complexities and dynamics of crisis and crisis management. Quarantelli et al. (2007) further claim that the area of disasters and crisis is changing and new types of risks and hazards as well as changes in social settings are emerging.

Published research indicates that the final outcome of a disaster is highly dependent on early preparations and training made before the crisis outbreak (Sundelius et al., 2001). Boin and 't Hart (2007) here argue that earlier crisis offers a good learning source for feasible planning and preparations for future ones. However, the capability of organizations to adjust to new conditions and policies is limited, and some researchers even claim that collective learning is not possible in complex organizations (Perrow, 1999).

Simulation and scenarios can be used to achieve organizational learning and research in this area (Burt & Chermack, 2008; Kljajić et al., 2007; Ekker & Eidsmo, 2006). Multi disciplinary based knowledge is, however, critical to accomplish simulation models and scenarios as realistic tools for emergency planning and intervention. Santos and Aguirre (2004: 44) writes: "…*research and theory in the social sciences can have an important effect in grounding the models in realistic assumptions regarding social behaviour in crisis situations, and such modelling in turn could enrich our understanding of collective behaviour in crisis situations*". Also theories of sense making and trust in and between organizations, and earlier research of crisis management and organizational learning (e.g. Asproth, 2007; Asproth & Håkansson, 2007; Asproth & Nyström, 2008), will be of interest for further research in this area.

The process oriented emergency management approach addresses the crucial issue of different understandings of the emergency situation. Today emergency training and simulation tools assume that involved organizations and individuals have the same image, or view, of the emergency site/situation, although empirical evidence indicate differently (Alvinius et al., 2007; Danielsson et al., 2007). Different organizations, as well as individuals within organizations, understand the situation differently depending on their task, position, information, knowledge, organizational culture and preparedness for action. The concept of sense making has proved to be useful for understanding this phenomenon (Weick, 1998; 2005). It can be understood as a process of placing stimuli or phenomena into context or a framework (e.g. organizational culture). There are few studies of how emergency management works at an international emergency site with actors not only representing different kinds of rescue agencies, public and private organizations and volunteers, but also different countries. However, the need to train and educate emergency agencies in handling such situations is vital.

McEntire (2007) has explored what is known about official and unofficial participants in emergency management at the community. The actors can be of different types (e.g. human beings, organisations, rescue teams etc. and it can be stated that there are many types of actors involved in a disaster.

Social scientific research has repeatedly showed that emergencies are characterized by complexity, dynamic but

rational behaviour, and that models based on continuity, coordination, cooperation, process and improvisation are more adequate than traditional rigid views on involved organizations and the emergency process (e.g. Alvinius et al., 2007; Rodrígues et al., 2006; Olofsson, Öhman & Rashid, 2006; Wachtendorf & Kendra, 2006). Still, emergency management, and related fields e.g. crisis communication, emergency organizational learning, training and simulation, are generally handled and studied as an intra, rather than an inter, organizational phenomenon (Danielsson et al., 2007; Fearn-Banks, 2002; Gordon, 2008; Olofsson, 2007).

Also organizational cooperation is mandatory in all kind of emergencies and current trends indicate that the future brings challenges to involve a wider range of actors from different regions and countries, i.e. demanding more complex collaborations (e.g. Caruson & MacManus, 2008; Quarantelli, 2006).

Disasters create a large number of victims, disable transportation systems, and place excessive demands on first responders, i.e. ordinary citizens who happen to be on the disaster location. Many important and urgent post-disaster needs cannot be addressed quickly or adequately by the official rescue organisations. Hence, bystanders and victims do not simply wait for any rescue team to show up. They take initiative to care for themselves and for others. Research has consistently shown that citizens engage in emergency response after a disaster (Drabek & McEntire, 2002).

Research has also shown that the human desire to help those in need is nearly an incontestable fact in nearly every type of disaster. People join together to complete tasks that often include rescue of victims. According to Dynes (1970) emergent groups are different than other types of organisations. Stallings and Quarantelli (1985) claim that these groups undertake activities that were previously foreign to them and develop a social structure that lacks formalization, tradition, and endurance. In contrast, an established organization performs routine functions in a disaster and maintains its traditional organizational relationship with the chief and subordinates.

Poteyeva et al. (2007) further claim the need for an international program of public education on first aid and emergency medicine. Such a program also ought to teach people what to do if they become and how to work as first responders.

Accordingly first responders are crucial in disaster management and the information to the public, i.e. the citizens are of great importance. Drabek (2007) even claims that future research ought to develop a theory of disaster response and emergency management.

The acceptance and application of earlier research results, however, must be made with some reservations. This since even if many important insights have been gained concerning disasters and crisis management there are still numerous questions of paramount importance remaining to be answered. Further, several of the results quoted here are, at least apparently, contradictory and a great part of them have not yet been field tested and verified in practical disaster work. With that said, the development of NetAgora system work here will build on the following compilation of current research insights:

- Final outcome of a disaster is highly due to preparations and training
- Many types of actors with different skills and cultures will be involved during rescue and recovery
- Communication and Coordination will be more important than Command and Control
- First responders are of paramount importance in rescue work
- The quality of information to the public (citizens) will be a crucial factor

A last observation of a more epistemological nature may be that most of the cited researchers apply a mono methodological approach, each advocating their specific research approach as the best and only successful one. Despite that, the netAgora endeavour will stick to a systems based multi methodology.

4 The netAgora environment

In trying both taking care of current research insights and meeting the requirements of the FP7 call we here propose the development of the netAgora environment. Hence, within the netAgora project a computer and net based integrated environment for mutual preparation and training for disasters and complex emergency situations should be developed. The netAgora environment will be all comprehensive with a disaster simulator, a scenario editor, and an assessment kit included in its core. It will support cooperation, coordination, training, preparation, and learning on individual, group, and organisational levels. The netAgora should further include support for an exchange of experiences, tools, and models of response to emergence situations within and between nations with a special emphasis on handling the cultural differences that may impede the emergence response.

Main components in netAgora are shown in Figure 3. The Virtual Situation Room (VSR) is the interaction surface toward the user. Through this surface (GUI) the user has access to all the other resources of netAgora. VSR may be freely adopted to meet the specific requirements of different user categories. There is no theoretical limit to the number of users that may simultaneously be connected to netAgora.

The Virtual Responder (VR) is a system component, which simulate the behaviour of other responders. From the point of view of the player there is no difference between a virtual actor and a real actor. This means that in netAgora there are always several actors, real or virtual ones, which you as user have to coordinate and communicate with.

The Disaster Simulator (DS) is the core of netAgora. DS can calculate (simulate) the dynamic evolution of a set of crucial disaster variables and react on different user decisions and actions. The ability to handle geographical or spatial information (GIS) is a crucial faculty of the Disaster simulator. The user can select a scenario, i.e. disaster, from

the Scenario Bank (SB) or set up a new one, or change an existing one, with help of the Scenario Editor/Generator (SEG). The Assessment Kit (AK) helps the user to evaluate the decisions and actions taken during the playing of a scenario.

Experiences and Lessons Learned (ELL), at last, is a knowledge bank with tested and verified disaster and crisis knowledge. Via the Meeting and Cooperation Support (MSC) the user can interact and discuss with other disaster responders and via the Expert Panel (EP) she or he can put disaster related questions to a group of disaster experts and disaster researchers.

In short, the main objective of netAgora is to provide, in one place, all the necessary resources and functions for best possible pan European preparation, training, and learning in relation to crisis and complex emergency situations.

Those objectives will be reached by developing the netAgora environment as a training tool and disaster simulator that are: inter active, situation flexible, cross platform, co-creating, computer and net based, based on open source, and usable in different social situations.

In summary, the netAgora project will ensure the future security of European citizens by:

- Rising awareness and preparedness of potential disaster responders by help of the components and resources in the netAgora environment.
- Improving cooperation and coordination between responders, even in different European nations, by help of the netAgora tools.
- Improving competence and performance of organisations involved in security issues.
- Bridging cultural and gender differences between responders from different nations and different backgrounds.

Further, tnetAgora project will improve the competitiveness of the European security industry by:

- Providing tools and methods based on high-end and emerging technologies within information and communication technology (ICT).
- Increasing the competence within simulation and decision support for security applications.
- Opening up an increasing market for supply and support of security related applications.

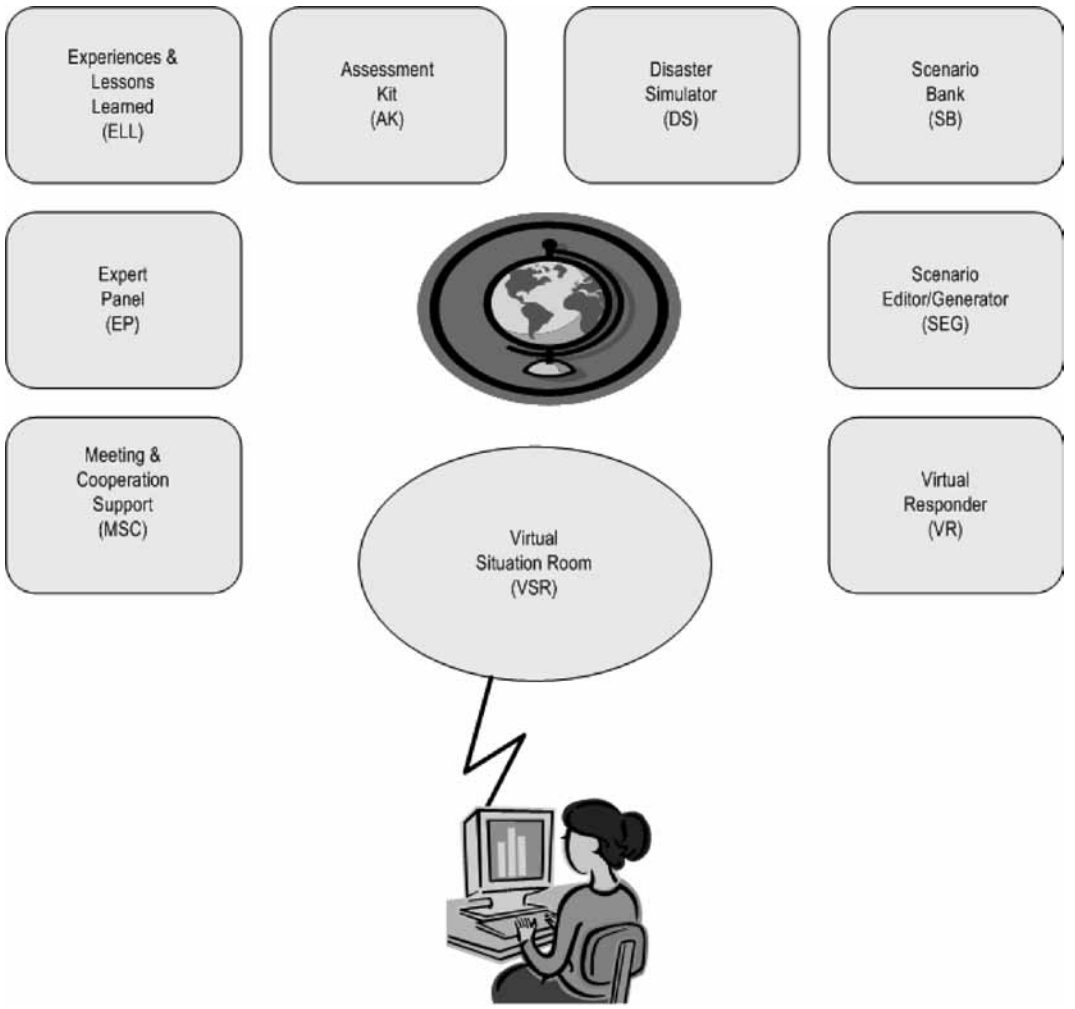

Figure 3: The netAgora environment.

5 Scenario creation

The project departures from two distinct points. Those are first the potential future users of netAgora and their needs, wishes, and requirements. The second departure point is the existing stock of open source tools and development environments. With this launching platform established it is the task of block two to design and construct both a set of test scenarios and the netAgora environment with its disaster simulator and other training tools. With a first version of netAgora environment up and running it will be the task of the last block to have normal users from different user categories to run the disaster simulator and environment with the different test scenarios and to evaluate the outcome of those tests. Those evaluation results will be used in correcting faults and in improving the tools.

The objectives of the development of test scenario and test data retrieval are:

- To create a realistic and dynamic scenario of an international disaster involving a large set of actors representing public, private and non-governmental organisations. The scenario will be based on previous disasters and possible future emergencies.
- To design the scenario so that involved actors are trained in mitigating the disaster through intra- and inter-organizational cooperation including communication failure, conflict and confusion. This will facilitate a learning situation based on network management rather than control and command.
- To retrieve data from previous national and international disasters in Europe, as well as to map the different structures of emergency management in target European countries, to constitute the base for building the scenario.
- To interact in the development of the complex emergency model implementing the scenario in the model.

The creation of emergency situation scenarios is not a trivial task and as it is specific, traditional scenario creation methods are not totally adequate and applicable. Scenario planning is a method to develop scenarios following a structured process (Schoemaker, 1995; Lindgren and Bandhold, 2003; Borglund and Öberg, 2007). The fundamental ideal is to provide a structured way to create a dynamic interaction between the environment and an organization to cover a broad range of future possibilities and future uncertainties and to expand people's thinking (Ellis and Shpielberg, 2003; Schoemaker, 1993; Wack, 1985; Weick and Quinn, 1999). An adjusted model of scenario planning can be a support for creation of emergency situation scenarios. Systems thinking used in conjunction with scenario planning leads to plausible scenario story lines because the causal relationship between factors can be demonstrated.

5.1 Retrieving test data

In accordance with the tradition of scenario development the following steps will guide the work: The kind of emergency of interest will be identified and defined, as well as the major stakeholders and/or actors affected and influencing the emergency. Based on these definitions, two to three previous national and/or international disasters will be indentified and described in detail. Focus will be put in involved actors, decision making, cooperation, management communication, position frames and outcome. The emergency management systems planned to be applied in four countries, Greece, Slovenia, Norway and Sweden will be mapped and described in detail to facilitate input to the scenario. Further, expert interviews with key actors will be done to include state of the art insights to future developments of disasters and emergencies in Europe. The development of a plausible scenario depends on the input and in this case it is crucial that realistic organizational structures in the different countries are included.

5.2 Development and building of scenarios

Based on the retrieved test data, a realistic scenario will be developed according to state of the art proceedings. Researchers and users will compose a scenario building group. The retrieved data will be analysed and complimented by brainstorming and analytical thinking, e.g. identifying current trends and predetermined elements that will affect factors of interest. A basic scenario will be built where different factors are organized as a matrix or grid to show interlinkages and causal relationships. Thereafter narratives and images will be developed. At this stage, plausibility, consistency and challenge of the scenario will be assessed by focus group interviews with expert and user groups. Last, the scenario will be modified, inconstancies eliminated and tested again until it is usable.

5.3 Implementing scenario with the emergency model

The scenario will be converted into the emergency model which means that the teams working with the workpackages will collaborate in translating the scenario to the macro- and microscopic models. The scenario will once again be tested to see if it is consistent and usable.

6 Validation

The netAgora design from section four above constitutes our result, or data, so far. At this stage of the project, however, one should note that design has not yet been implemented and field tested. Hence, we here have to limit ourselves to a theoretical validation against published research results.

First, netAgora is an idealized design in the meaning of Ackoff et al. (2006). This means that it is the best solution that the designers can imagine or conceptualize at the time being. Hence, the initial design proposed by the development of NetAgora System plays an important role as a

source for continuous improvement according to Simon's (1996) principle for constructive critique.

Nyström (2006) has shown that many web applications are used just to a tiny fraction of their full potential. On the other hand, she also finds that if properly designed they may be a source of empowerment and emancipation. By given the users an active role in filling the site with content and by opening up for communication between the users the chances for a well used site seem to increase. Those facilities are provided in netAgora increasing the possibilities for a successful implementation.

6.1 Living systems theory

Living Systems Theory (LST) defines twenty critical subsystems or critical functions that are required for guaranteeing sustained life in any living system (Miller, 1978). This makes LST an excellent tool for judging the viability also of artificial systems. Hence, the crucial question here is weather netAgora is viable or not according to LST?

The answer is not entirely evident. First, there is no direct correspondence between the functions of netAgora and all of LST's twenty critical subsystems. Among other things, the eight subsystems handling energy and matter are completely lacking in netAgora. On the other hand, if the human user is taken as part of the netAgora system it per definition becomes a living one. Hence, with the human user included netAgora is a living system with some of its functions supported and enhanced by artificial help systems, or artifacts. So the initial question becomes, in what ways could the artificial part of netAgora provide an even better support?

One requirement that is not explicitly met in the current design is the need to gap cultural and institutional differences between different parts of Europe. LST here has to provide the subsystems decoder and encoder, i.e. the subsystems responsible for translating between internal and external system languages and codes. By explicitly incorporating those functions into the netAgora design the bridging of cultural differences could be handled more effectively.

Further, by adding the subsystem Internal Transducer netAgora would develop into a monitoring, "world watch", system. In this way the link between the internal model world and the external object world would become stronger. This could then be a first step of developing netAgora into a Soft Early Warning System according to ideas put forward by Holmberg (2008).

Geographical information (GIS) is a central component in netAgora. This is fully in line with LST where Miller (1978) points out that three dimensional Euclidean space is the only space common to all concrete living systems. In order to support this finding, Asproth et al. (2006) have already defined guidelines for spatial planning based on anticipatory, fuzzy, and constructivist principles.

6.2 Critical systems heuristics

In any systems application you have to draw a system boarder, i.e. to decide what to take into account and what to leave out. The systems approach may help you see better and understand better what fall within the system border but at the same time it makes you blind for what falls outside of that boarder. The location of the system border, however, is seldom obvious. In most cases there are numerous alternatives at hand. Each giving most different output or result of the systemic work. As a consequence, deciding on the system border becomes a critical step in all system applications. Critical Systems Heuristics (CSH) (Ulrich, 1994) does not stipulate where to draw the border but it helps you see the consequences of different alternatives.

Table 1: The boundary questions.

SOURCES OF MOTIVATION
(1) Who is the client? That is, whose interests are served?
(2) What is the purpose? That is, what are the consequences?What is the measure of improvement? That is, how can we determine that the consequences, taken together, constitute an improvement?

SOURCES OF CONTROL
(4) Who is the decision-maker? That is, who is in a position to change the measure of improvement?
(5) What resources are controlled by the decision-maker? That is, what conditions of success in securing improvement can those involved control?
(6) What conditions are part of the decision environment? That is, what conditions lie outside the decision-maker's control?

SOURCES OF KNOWLEDGE
(7) Who is considered a professional? That is, who is involved as an expert, e.g. as a systems designer, researcher, or consultant?
(8) What expertise is consulted? That is, what counts as relevant knowledge?
(9) What serves as source of guarantee? That is, who or what is assumed to make sure that improvement will be achieved (e.g., consensus among experts, stakeholder participation, the experience of those involved, the methods used, political support)?

SOURCES OF LEGITIMACY
(10) Who is witness to the interests of those affected but not involved? That is, who voices the concerns of stakeholders who are not involved or cannot speak for themselves, including future generations and non-human nature?
(11) What secures the emancipation of those affected from the premises and promises of those involved? That is, where does legitimacy lie?
(12) What *worldview is determining? That is, what visions of "improvement"*
are considered, and how are they reconciled?

Ulrich (1994) has provided a list with twelve boundary questions. With help of those questions it becomes possible to assess the boundary decisions you have made and to compare them with alternative ones. Those questions in slightly modified form are given in table 1.

The questions in the given form identify the actual border. By changing the verb is/are to ought/should they help you see alternatives, i.e. new things to take into account and old things to let out.

The boundary questions will not be answered here. Instead we invite our readers to apply those questions on the netAgora design in section four. In this way this paper will lead to a third generation design according to Banathy (1996). The vision for this type of design, i.e. that everyone being impacted by a new system also have to take part in its design, may seem too idealistic. Anyhow, as shown by Löfstedt (2008) third generation design may be applied with some degree of success to this type of development projects.

7 Conclusions

The insights gained and lessons learned from this initial work is highly preliminary and have to be further verified and refined during successive project steps. Hence, for the time being it is just possible to say that:

- In working with colleagues from all over Europe, it has become clear that security and security preparation activities are highly urgent issues for most, if not all, EU member states. The local conditions, threats, and organisation of crisis management, however, may vary highly from one member state to another one. Those differences, hence, have to be taken care of in any solution approach.
- From our critical review of current research results it has further become evident that preparation and training are the most crucial parts in any system for crisis and disasters management.
- The netAgora design will meet most pan European needs for an integrated learning, training, preparation, and communication environment.
- The realism and trouthfulness of netAgora, however, will be of crucial importance. Hence, great effort has to be put into the work of capturing scenarios and events from the real world and incorporating them into the netAgora tool.
- It has also become evident that disaster situations will change all the time. New threats will emerge and at the same time differences between differents part of EU will remain. Hence, a system for feedback and continuous learning will also be a most important part of the netAgora environment.
- In using Internet and the web as a main veichle for netAgora many practical problems have been solved automatically and the training tool will be available for everyone who needs it, all over Europe.
- The combination of technical and social research competence in the project team has turned out as being of paramount importance.
- A systemic framework like Living Systems Theory and a systemic design method like Idealized Design have been good intellectual tools for this type of Operational Research application.
- Critical Systems Heuristics and principles for third generation design can be applied for continuous improvement of the design.

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Simulacija skupinskega odločitvenega procesa in učenja

Ideja analize skupinskega odločitvenega procesa in posledično identificiranega učenja ima bogato tradicijo v okviru področja operacijskih raziskav. V prispevku je izveden nov korak v smeri izboljšave rezultatov skupinskih odločitvenih procesov na področju upravljanja v kriznih situacijah. Uvedeno je okolje kjer sodeluje več udeležencev, ki istočasno sprejemajo odločitve na podlagi delnih informacij, ki jih medsebojno izmenjujejo. Člani odločitvene skupine za odločanje uporabljajo simulacijski model, kar ima številne prednosti v primerjavi z delovanjem v realnih sistemih.

Ključne besede: večnivojski sistemi, anticipacija, zakasnitev, učenje, simulacija

Chandra Sekhar Pedamallu, Linet Ozdamar, LS Ganesh, Gerhard-Wilhelm Weber, Erik Kropat

A System Dynamics Model for Improving Primary Education Enrollment in a Developing Country

The system dynamics approach is a holistic way of solving problems in real-time scenarios. This is a powerful methodology and computer simulation modeling technique for framing, analyzing, and discussing complex issues and problems. System dynamics modeling is often the background of a systemic thinking approach and has become a management and organizational development paradigm. This paper proposes a system dynamics approach for studying the importance of infrastructure facilities on the quality of primary education system in a developing nation. The model is built using the Cross Impact Analysis (CIA) method of relating entities and attributes relevant to the primary education system in any given community. The CIA model enables us to predict the effects of infrastructural facilities on the community's access of primary education. This may support policy makers to take more effective actions in campaigns that attempt to improve literacy.

Keywords: developing countries, system modeling, cross impact analysis, simulation, system dynamics, primary education

Carlos A. Legna Verna, Andrej Škraba

A Methodology for Improving Strategic Decisions in Social Systems with a Lack of Information

The design of strategies for social systems requires the use of qualitative information owing to the fact that quantitative information can be insufficient to solve the problems involved. The information that the specialists and the decision makers obtain is often incomplete and unreliable. Nevertheless, leaders have to make strategic decisions despite these deficiencies which should be based on the formal models (Kljajić et al. 2000; Škraba et al, 2003; Škraba et al 2007).

This paper describes a methodology elaborated to design the strategy of the city of Santa Cruz (on the Canary Islands). It has two main sections: the elaboration of a qualitative model and the use of System Dynamics. We combine them in a way that allows mixing qualitative and quantitative information to achieve a better understanding of the structure of the region, to know the tendencies of the present scenario and to estimate of the effects of alternative strategic decisions. We have obtained these results working with scarce quantitative information. This methodology may be applied to any social systems with similar characteristics.

Key words: Qualitative models, System Dynamics, Social Strategies

Ingvill C. Mochmann, Dorien J. DeTombe

The COMPRAM Methodology and Complex Societal Problems – an Analysis of the Case of Children Born of War

During and after wars children are born where the father is a member of an occupation or peacekeeping force and the mother a local citizen. Securing the human rights of children born of war is often highly complex and involves researchers and practitioners from different disciplines. The Compram methodology on handling complex societal problems will be applied to analyse whether the methodology is suitable on this group of war-affected children. The Compram methodology is a multi disciplined, multi level, multi actor methodology based on the theory of societal complexity. The methodology gives guidelines to handle real life complex societal problems.

Keywords: OR in societal problem analysis; Taboo research; COMPRAM methodology; children; war.

Davorin Kofjač, Andrej Knaflič, Miroljub Kljajić

Development of a Web Application for Dynamic Production Scheduling in Small and Medium Enterprises

This article describes the development of a web-based dynamic job-shop scheduling system for small and medium enterprises. In large enterprises, scheduling is mainly performed with appropriate technology by human experts; many small and medium enterprises lack the resources to implement such a task. The main objective was to develop a cost-effective, efficient solution for job-shop scheduling in small and medium enterprises with an emphasis on accessibility, platform independence and ease of use. For these reasons, we decided to develop a web-based solution with the main emphasis on the development of an intelligent and dynamic user interface. The solution is built upon modular programming principles and enables dynamic scheduling on the basis of artificial intelligence, i.e. genetic algorithms. The solution has been developed as a standalone information system, which allows the management of virtually all scheduling activities through an administration panel. In addition, the solution covers the five main functionalities that completely support the scheduling process, i.e. making an inventory of resources available in the company, using it in the process of production planning, collecting data on production activities, distribution of up-to-date information and insight over events in the system.

Keywords: dynamic job-shop scheduling, genetic algorithms, web application development, web user interface, small and medium enterprises

Viveca Asproth, Stig C Holmberg, Ulrica Löfstedt

Simulated Decision Learning in a Multiactor Setting

The idea of decision analysis – and subsequent learning from the outcomes – is old within Operational Research. Here this approach to continuous improvement of decision outcomes is put one step further within the area of crisis and disaster management. This is done by introducing multi-actors making simultaneous decisions with just partial information about each other. Further, decision outcomes are achieved from a simulation model rather than from the real object system.

Keywords: Multi Layered Systems, Anticipation, Retardation, Learning, Simulation.

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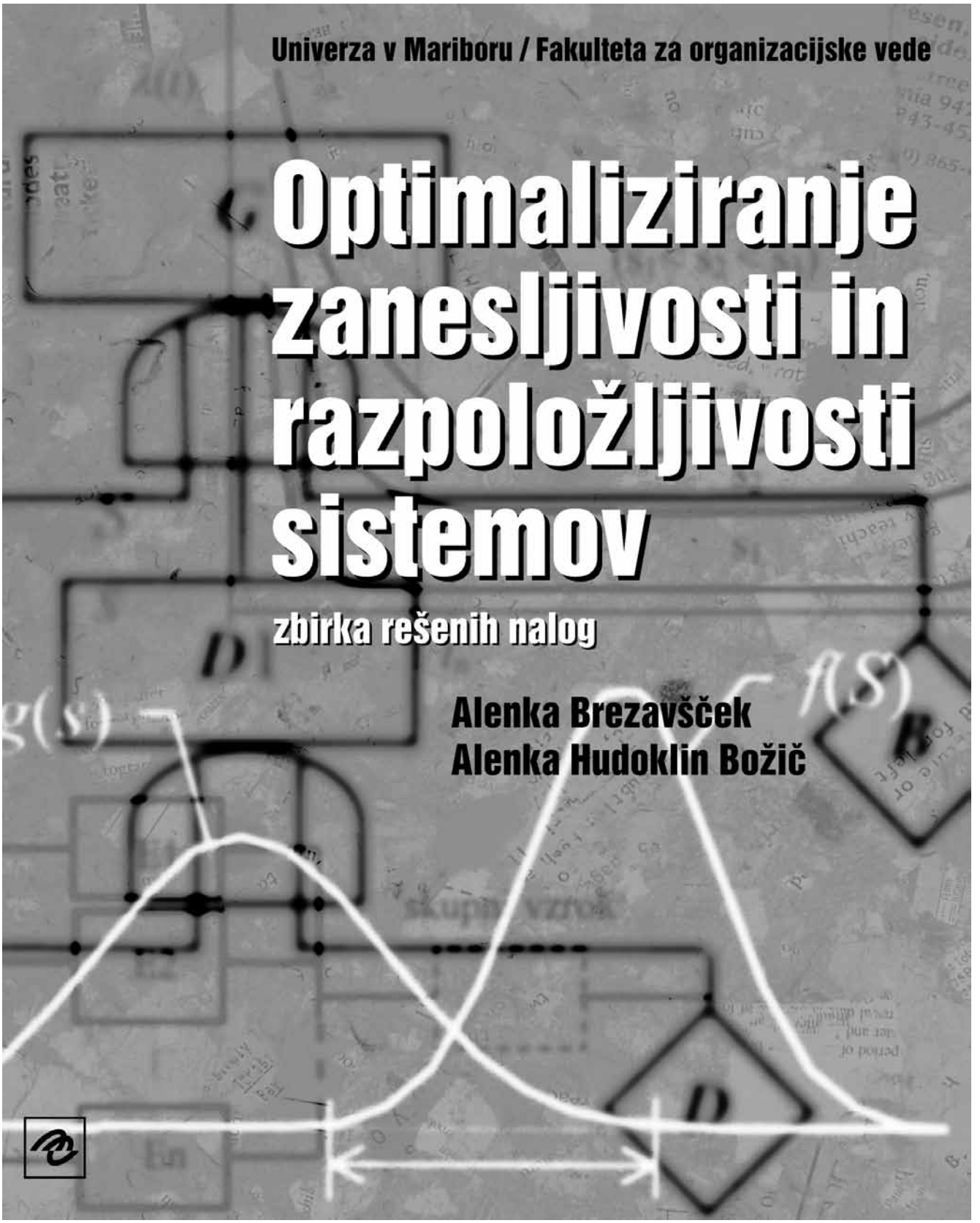
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Navodila avtorjem prispevkov

V Organizaciji objavljamo razprave (znanstvene članke, rezultate raziskovalnega dela avtorjev, ali pregledne članke), predloge za prakso (strokovne članke, na primer prikaze in ocene pristopov in metod in njihove uporabe v praksi), razmišljanja (krajši prispevki), informacije in knjižne ocene. Občasno vključujemo tudi odmeve na objavljene prispevke, enciklopedične razlage, intervjuje s strokovnjaki s predmetnega področja revije in druga besedila. Približne omejitve dolžine prispevkov so naslednje:

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- knjižne ocene, odmevi: do 5.000 znakov.

V reviji objavljamo prispevke v angleščini in slovenščini. Razprave in predloge za prakso ocenita vsaj dva recenzenta, druge prispevke pa uredniški odbor ali urednik. Na osnovi mnenja recenzentov uredniški odbor ali urednik sprejmejo prispevek, zahtevajo manjše ali večje popravke ali ga zavrnejo. Če urednik oziroma recenzenti predlagajo večje popravke, se prispevek praviloma ponovno pošlje v recenzijo. Urednik lahko sprejeti prispevek pošlje v lektoriranje. Lektorirana besedila se lahko vrnejo avtorju v pregled.

Besedilo naj bo oblikovano za tiskanje na papirju formata A4 s presledkom med vrsticami vsaj 1,5 levo poravnano. Razpravam in predlogom za prakso naj bo dodan povzetek (izvleček) dolg 10-20 vrstic, ključne besede, v končni – sprejeti verziji članka pa na koncu prispevka tudi kratek strokovni življenjepis vsakega od avtorjev (do 10 vrstic) in letnica rojstva (zaradi vnosa podatkov v knjižnični informacijski sistem COBISS, v reviji letnica ne bo objavljena). Na prvi strani besedila naj bodo napisani le naslov prispevka, imena in (poštni in elektronski) naslovi avtorjev članka, po možnosti tudi telefonska številka enega od avtorjev. Da bi zagotovili anonimnost recenziranja, naj se imena avtorjev ne pojavljajo v besedilu prispevka.

Članek naj bo razčlenjen v oštevilčena poglavja. Naslovi članka, poglavij in podpoglavij naj bodo napisani z malimi črkami, da so razvidne kratice. Povzetek naj na kratko opredeli temo, ki jo obravnava prispevek, predvsem pa naj na kratko, jasno in čimbolj preprosto povzame poglavitne rezultate, zaključke, ugotovitve..., prispevka. Splošne ugotovitve in misli ne sodijo v povzetek; uvrstite jih v uvod. Povzetek je namenjen predvsem bralcem, ki listajo po reviji (ali pregledujejo izbrane povzetke iz baza podatkov) z namenom, da rezultate Vašega članka uporabijo pri svojem delu, na primer v raziskavi, pri pisanju diplome, magisterija, doktorata, … Na osnovi povzetka naj bi bralec presodil, ali se mu splača prebrati (ali kopirati, natisniti, …) cel članek. Povzetek zato ne sme biti neke vrste »preduvod«.

Povzetek, naslov članka in ključne besede naj bodo tudi prevedene v angleščino.

Slike in tabele v elektronski obliki vključite kar v besedilo. Besedilu so lahko priložene slike in/ali tabele na papirju v obliki pripravljeni za preslikavo. V tem primeru naj bo vsaka slika na posebnem listu, oštevilčene naj bodo z arabskimi številkami, v besedilu naj bo označeno, kam približno je treba uvrstiti sliko: na tem mestu naj bo številka slike/tabele in njen podnapis. Slike bomo praviloma pomanjšali in jih vstavili v članek. Upoštevajte, da morajo biti oznake in besedila na vseh slikah dovolj velika, da bodo čitljiva tudi pri velikosti slike, kot bo objavljena v reviji. Vse slike naj bodo črno-bele z belim ozadjem; barvnih slik ne moremo objaviti.

Pri sklicevanju na literaturo med besedilom navedite le priimek prvega avtorja, oziroma prvega in drugega (glej vzorec), letnico izdaje, lahko tudi stran. Popolni bibliografski podatki naj bodo v seznamu literature in/ali virov na koncu prispevka, urejeni po abecednem redu (prvih) avtorjev, literatura istega avtorja pa po kronološkem redu izida; če navajate dve ali več del nekega avtorja oziroma avtorjev, ki so izšla v istem letu, uporabite črkovno oznako pri letnici, na primer 2003a, 2003b, ... V seznamu literature in/ali virov ne navajajte del, ki jih ne omenjate v besedilu članka. Ne uporabljajte opomb za citiranje; eventualne opombe, ki naj bodo kratke, navedite na dnu strani. Označite jih z arabskimi številkami.

V seznamu lahko ločite literaturo (članki v revijah, knjige, zborniki konferenc, doktorske disertacije, …) in vire (dokumenti, zakoni, standardi, interni viri, …). Pri citiranju literature uporabite enega naslednjih načinov, ki so prikazani na naslednjih primerih:

- "... v nasprotju z (Novak in Vajda, 1996:123) raziskava (Wilkinson et al., 2001:234) nakazuje, da ..."
- "... kot poročata Smith (2003) in Jankowski (2004) metodo uporabljajo za ..."
- "... kot ugotavljajo nekateri drugi avtorji (Zima 1999; Novak in Vajda, 1996; Wilkinson et al., 1993), številna podjetja ....".

Bibliografske podatke v seznamu literature navajajte na "harvardski način", kot to kažejo vzorci v nadaljevanju:

Članek v reviji:

- Novak, A. & Vajda, B.M. (1996). Effect of surface runoff water on quality measurement, *European Journal of Information Systems*, 31(4): 31 - 39.
  Zraven letnika v oklepaju navedite številko v letniku le, če se vsaka številka začne s stranjo 1. Če revija nima letnika, lahko navedete mesec ali drugo ustrezno oznako, na primer Poletje 1999.

Članek v elektronski reviji:

- Lynch T. & Szorenyi Z. (2005). Dilemmas surrounding information technology education in developing countries, *The Electronic Journual of Information Systems in Developing Countries*, 21(4): 1-16, dosegljivo na: http://www.ejisdc.org (22.8.2005).

Knjiga:

- Smith, S.I. (2003). *Interpreting Information Systems in Organizations, Elsevier Publishing, New York.*

Poglavje v knjigi:

- Zupan, N. & Leskovar, R. (2002). Pričakovanja v zvezi z elektronskim poslovanjem v malih organizacijah. *Organizacija in management – izbrana poglavja.* Uredila: Florjančič J.,& Paape, B. Kranj: Založba Moderna organizacija.

Referat objavljen v zborniku konference:

- Wilkinson, K.J., Kumar, R. & Kumar, S. (2001). We can do better: integrating theories of novel organizations, *Proceedings of the Twelfth European Conference on Information Systems.* Uredil: Johnson, M. Bled 12-14 Jun. 2001. Berlin: Springer Verlag,

Diploma, magisterij ali doktorat:

- Zima, B. (1999). Analiza potrebnih znanj diplomiranih informatikov v Sloveniji, magistrsko delo, Univerza v Mariboru, Fakulteta za organizacijske vede.

Poročila, interni dokumenti, zakoni:

- ACM (1994) ACM SIGCHI Curricula for Human-Computer Interaction, The Association for Computing Machinery, New York.
- Zakon o elektronskem poslovanju in elektronskem podpisu (ZEPEP), Ur.l. RS, št. 57/2000, 30/2001

Pri internetnih virih / literaturi naj bo poleg (eventualnega avtorja in) naslova besedila naveden tudi internetni naslov vira (URL) in datum dostopa do dokumenta.

- Banka Slovenije, Basel II – Nov kapitalski sporazum, dosegljivo na: http://www.bsi.si/html/basel2/default.htm (6.4.2005).

V literaturi ne navajajte internetnih naslovov (URL) brez drugih podatkov. Lahko pa se nanje sklicujete v besedilu ali v opombah na dnu strani. Podrobnejša navodila glede citiranja in navajanja literature so na http://versita.com/science/business/organizacija/authors/.

Predloženi prispevki naj bodo lektorirani. Prispevke v angleščini naj pregleda in jezikovno uredi lektor ali lektorica, ki mu/ji je angleščina materin jezik. Uredništvo s soglasjem avtorja lahko posreduje prispevek v lektoriranje. Stroške lektoriranja krije avtor.

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