The Use of the SaGa Tool for Scenario-based Planning

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Abstract

This paper describes the Scenario Generator (SaGa) tool that prepares "plausible" futures for use in developing - or testing - managerial plans. SaGa generates adaptive, written scenarios based upon some of the power of systems thinking.

SaGa produces scenarios from the combination of textual and numeric values that are linked into cascades of formulae or decision tables. It provides a written description of the implications of using different sets of input values in a model of complex systems behaviour. Managers with preferences for verbal material can then use these scenarios to consider what preparations should be made to achieve their preferred future.

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Uses of Scenarios

Scenarios have five main uses. They have been used for over 20 years in technological forecastir for corporate plans[1], in building hypothetical circumstances against which alternatives can t evaluated[2], in testing for the suitability of human-computer interfaces[3], in experimental gaming ı explore decision-making processes[4], in constructing rich sets of variables for testing hypotheses and in preparing case-studies for management education[6].

In essence, scenarios can help in predicting, understanding, and learning about planning skills ar processes. They can: build possible futures; model the consequences of taking actions; and for case studies for use in practising skills or to learning concepts. This paper describes the first tw uses of scenarios.

Scenarios can be used in future studies for two reasons:

a. to "predict" the future - so that managers can arrange resources to get ready for it or

b. to provoke thoughts about what would be necessary "as if" the particular futui occurred, in order to test the quality of planning or gather ideas or judgements abo better processes.

Forecasting may not be a matter of prediction but of making assumptions about the future that lead decisions about precautions to take now[7]. Scenarios can be treated as if they were not forecasts b opportunities for managers to understand the "... role of uncertainties and become prepared to tal informed decisions that take a range of possible developments into account."[8]. In this usag scenarios can be used to test or select options according to their perceived impact upon tl hypothetical situations.

Scenarios can build ".... intuitive, holistic, views of plausible realities or futures"[9] - that a corporate visions. There is a strong and growing move to the use of visions as the focal point f corporate and Information Systems planning[10].

Scenarios can provoke discussions of issues. They can be used to explore how different peop perceive the future, in order to see if there is any common ground in their perceptions of what are tl important issues[11]. They can encourage detailed considerations of cause-and-effect, as well strengths and weaknesses of plans. They can support building "future state visions"[12].

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1 See Garrett (1993), Godet (1987), Makridakis (1990), Martino 1972) for examples of how scenari have been used in technological or economic forecasting.

2 O'Connor and Edwards (1976)

3 See Campbell (1992), Nardi (1992) for the debate about the value of scenarios, of various types, testing the 'useability' of interfaces for computer systems

4 Moynihan (1987), Pruitt and Kimmel (1977)

5 Kirs, Sanders, Cerveny, and Robey (1989)

6 Graham (1988)

7 Ackoff (1993) makes this point well: we do not have to forecast a flat tyre will occur on this trip order to carry a spare; we only need to assume that one will be needed some day.

8 Bunn and Salo (1993)

9 Taylor (1991)

10 Ackoff (1993)

11 Kendall, Kendall, Smithson, and Angell (1992)

12 Stewart (1993)

Even the act of merely building the scenario can have an important role in clarifying assumptions or planning processes. "Forecasting is an art - on a scientific basis"[13] summarizes some of the approaches for the use of scenarios in forecasting.

There are different types of scenarios. Exploratory scenarios can be realistic but not surprising; anticipatory scenarios can be more surprising, leading to more ideas about possible options for action[14]. Other terms used to describe the different types of futures scenarios include: descriptive/ normative, trend/ peripheral, deductive/ inductive. In some uses of scenarios for forecasting, several scenarios are drawn up for different points along a time-line. In other cases, several scenarios are designed to show "most likely" or "most impact" futures at the one point in time[15]. There is a need to have different tools to prepare these different types of scenarios.

Scenarios should be credible, comprehensive, consistent, and coherent[16]. They should be plausible, representative, relevant[17], and transparent[18].

Difficulties with Scenarios

There have been constant debates about how scenarios should be constructed. These debates[19] include: whether causal or correlational cross-impact analysis should be used to determine the "most likely" combination of driving variables; how scenarios can be made internally consistent; how the bias of the experts building the scenarios can be avoided. If different scenarios are to be used, in order to ensure that the vividness of presentation does not lead to different responses, they need to have the same level of detail and imagery. Scenarios should be capable of bringing out the actions of actors in the scenario, even including role-playing[20].

Building a scenario for futures planning can take over 12 months[21], involving several people. Accordingly, the number of hypotheses, drivers, or variables captured in the scenario could be limited. There is a need for a tool that can be used readily to build a number of consistent scenarios.

Uses of Systems Dynamics

At the same time, Systems Dynamics models also have been used for a number of purposes. It has been used to model the effects of variables over time and with complex interactions, in order to describe, decide, or learn about the operations of business or physical systems.

Systems Dynamics models have been used to describe the behaviour of systems as part of forecasts, such as the Club of Rome models of natural resource consumption[22]. These descriptions have been used as the basis for recommendations for policy. They have been used for developing strategies for meeting the range of forecasted issues, such that contingency plans can be developed or the strategies are made flexible enough to apply across the likely range of futures[23].

Systems Dynamics has been used to explore the effects of alternative structures or controls upon the behaviour of systems, in order to improve the performance of the systems[24]. Models have been

13 Sviden (1986)
14 Bunn and Salo (1993, p293)
15 Schnaars (1987)
16 see Bunn and Salo (1993, p299)
17 O'Connor and Edwards (1976)
18 Godet (1993)
19 Bunn and Salo (1993), Godet (1976), Helmer (1977), Kelly (1976), Mitchell and Tydeman (1976), Schnaars (1987)
20 Bunn and Salo (1993, p297)
21 Godet (1993); Huss and Honton (1987) talk about prepring essays of 2-10 pages for each of the many descriptors that are to be included
22 Meadows, Meadows, Randers, and Behrens (1971)
23 MacNulty (1977); Mobasheri, Orren,, and Sioshansi (1989)
24 Wolstenholme and Coyle (1983) gives one example of this application of Systems Dynamics for the qualitative analysis of the performance of systems. Coyle (1985) gives an example of a quantitative analysis.

combined with multiple attribute utility theory in a decision conference to determine the best polic option[25].

Systems Dynamics models have been used to assist managers to learn about the behaviour of facto influencing the operations of their business, in order to build a "learning organization" that operat more efficiently and more effectively in a rapidly changing environment[26]. There has often been a interaction between systems dynamics and the use of microworlds or games to assist managers t learn about their business[27]. Managers can use these tools to learn about important variables[28], a the act of building the models increases the insight into the underlying relationships between th components of systems. There are examples of interactions between Systems Dynamics an scenario-based planning in areas such as analyzing the shortfalls in Defence requirements[29].

Systems Dynamics models can contribute to the production of case studies needed for manageme education that are "... a consistent and known environment for active learning"[30]. Generic mode can be developed to provide the framework for the case studies.

So, both scenarios and systems dynamics can be used to test the quality of planning or to bui planning skills.

Difficulties with Systems Dynamics

These systems dynamics models are very powerful but they need to be more understandable to wider range of people. Older dynamic modelling packages such as Dynamo or DYNSMAP[3 require detailed equations to represent time or event-linked relationships. These equations can b hard to build without a detailed knowledge of the semantics of modelling and the syntax of th package. As well, my anecdotal evidence suggests that it takes time to grasp how to represe generic models and to build realistically complex models. This time could be begrudged by bu managers.

The graphical outputs of packages such as *IThink* or *VENSIM* - the "visual spreadsheets" - do enab patterns to be seen at a glance and relationships to be traced in ways that are impossible in text.

However, many people are 'verbalizers', not 'visualizers', and they have considerable difficulty interpreting graphical material, either in the diagrams or in the graphically presented results[3 Many of the senior managers who would make use of scenarios come from legal, clerical, accounting backgrounds - they are verbalizers. There is a need for ".. word-and-picture maps to b built at the level of policies"[33]. There is a need for a method of building models of business that a readily understood by verbalizers as well as visualizers.

Of course, the quality of the systems dynamic model is a direct result of the quality of th relationships linking the variables in the model. Dimensional analysis, 0-1 testing, and oth techniques can be used to see that the equations of the model are internally consistent. The mode can be checked by experts to see if they do have at least some face validity. The models can b

25 Reagan-Cirincione, Schuman, Richardson, and Dorf (1991).

26 Of course, this use of systems dynamics is represented by the work from the Sloan school at MI exemplified by Senge (1990), amongst others. Others using systems dynamics for learning include Byrne a Davis (1991).

27 Morecroft (1988), who was once also of the Sloan School of Management

28 Senge (1990), Senge and Sterman (1992)

29 Coyle (1989)

30 Graham (1988)

31 Coyle (1985)

32 Lewis (1976) gives the most complete list of the 15 different cognitive styles, including the differen in the processing of visual information. Sage (1981) also describes the need for, but difficulty in, designi decision support systems that take account of cognitive styles.

33 Morecroft (1988, p316)

verified in some circumstances, even though the overwhelming number of permutations of variables usually prevents a complete verification and validation.

There is a need for a method for building the models such that the relationships between the variables can be validated and checked for consistency and completeness in their representation.

Summary of Needs

There is a need for a tool that can produce all types of scenarios, including models of complex systems, in written form. The tool must be capable of combining a range of values in a comprehensive, consistent, coherent, plausible, representative, relevant, and transparent manner.

The tool must be easy enough to use to produce several scenarios readily in order to test many plans or to give a wide range of experience to managers seeking to increase their understanding of systems behaviour.

Overview of the Design of SaGa

Intent of SaGa

This paper describes the SaGa computer-based tool that provides a single "architecture" for meeting the needs described above. It builds all the different types of scenarios, in a way that incorporates Systems Dynamics concepts.

Actually, there is a family of tools [34] based upon a common SaGa "engine". With slight variations in form, SaGa can provide: a set of scenarios containing a coherent set of factors that can be used to explore the consequences of taking action; a vivid description of a future situation, with a list that shows the actions, resources, and policies that are necessary to make that future feasible; a series of case studies that appear to be different on each presentation yet are based upon a common framework; a set of scenarios for a sequential time-frame, under different assumptions about the likelihood of the availability of various resources.

SaGa can be used for other planning tasks apart from these futures-oriented applications. It can be used to: analyze the processes used in organizations to determine where "process innovation"[35] best applies; generate options from lists of alternative components; determine the value-for-money of options in order to evaluate systems designs, policies, or tenders; and to represent the sequence of tasks needed to implement a chosen option.

Regarding the topics of this conference, SaGa supports many of the Sloan School facets of learning organizations[36]. SaGa can assist in developing personal mastery, through case studies to practise managerial skills or the Think! package that I use to overcome the heuristics and biases in human thinking. SaGa can help to build a shared vision, using the Future SaGa version that forms vision statements from requirements[37].

More pertinently, the version of SaGa described in this paper builds scenarios and mental models. These provoking scenarios and models can get managers to consider alternative futures, so avoiding fixation upon one mental model. SaGa can present systems dynamics thinking in verbal form. SaGa can help the learning organization in many ways.

Building SaGa

SaGa links snippets into sagas and scenarios. A snippet is a short description of an action or situation, incorporating the effects of linking one or two variables. A saga is a sequence of snippets

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34 currently written in a compiled form of Hypercard for the Macintosh and in ToolBook for the PC.

35 I prefer process innovation, the term used by Davenport (1993) rather than the "business process re-engineering" introduced by Hammer (1990).

36 as best represented in Senge (1990)

37 Lewis (1994)

arranged into a sequence that maintains a story-line. A scenario is a saga that involves the whole : of factors, linked in a complete and consistent way.

The extent of linkage between snippets determines the use of SaGa. Simple snippets give a test particular facts or procedures. A complex scene provides a test for planning processes.

The steps in building a saga are:

a. Write scene snippets.

b. Write snippets that describe the consequences of actions, including slots f variables whose values are determined by links to other variables.

c. Write descriptions of the alternative values for each variable.

d. Build links between variables and snippets, allowing the actions effecting t displayed values to depend upon the type of the links.

e. Build a script that shows the snippets in a coherent, realistic order.

Scenes

Scenes are descriptions of backgrounds for a saga. The scene describes the nature of t organization or the problem. For example, the scene could be a small business or an Army unit combat.

Often some scene snippets are given at the beginning of a scenario, as an introduction to the sto line. Other scenes can be inserted at various parts of the scenario, to build the atmosphere or ser of characterization. These scene snippets are a sentence or two, possibly containing a slot fo random insertion of other text. With randomly selected values it is possible to change t appearance of a scenario without altering its framework.

Embedded Variables

Each snippet can contain variables (or "slots") that will be filled by alternatives from a list of valu according to the selection method relevant for the snippet. For example, [#org.name] a [#econ.trend] are slots for variables that would insert an organization's name in place of the first s and a short descriptive phrase about the economy in the second slot.

Values are inserted in the slots when the scenario is formed. These values could be determined l random selections from lists provided by the author; the results from applying formulae upon a set input values; or the results of applying decision tables to the set of input values.

Linkages

It is the different linkages between variables and between snippets that gives the versatility to Sa(The different uses of SaGa come from either the different forms of the links or the different directic in which the links are followed.

The links can combine variables in formulae. These variables, in turn, could be either a function other formulae or direct input. SaGa can model systems behaviour when the formulae take acco of the effects of time and feed-back/ feed-forward links are used.

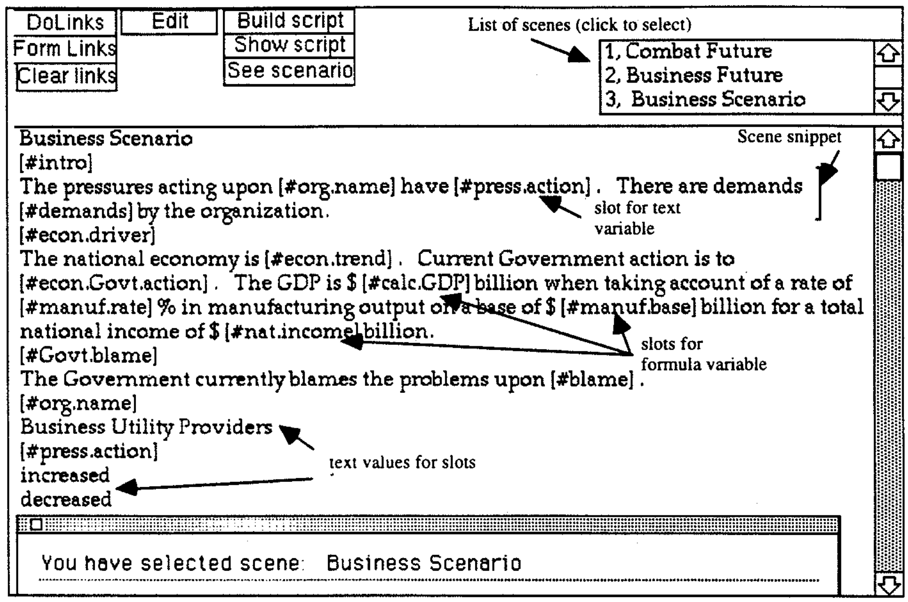
The links can form decision tables resulting from logical combinations. The logical links c represent probabilities or predicates. Fuzzy logic models can be formed from links representing t probabilities of association. SaGa can link logical values into Disjunctive Normal Form, representing any logical predicate[38]. In addition, the use of a decision table form enables SaGa

38 Lewis (1976) gives considerable detail about the use of "fundamental areas" (or DCF) to repres classification rules. This thesis showed that the sequence of information - such as a chain of exemplars - (have a marked effect upon the ability of humans to learn the classification rules. This sequence effect becon

provide compound causal cross-matrix analyses, which are not possible in most scenario planning approaches.

SaGa can be used to provide a frame-based expert system. The links can cascade through variables, using different signal strengths between 0 and 1 to represent the extent to which the presence of one variable or snippet "fires" another variable or snippet.

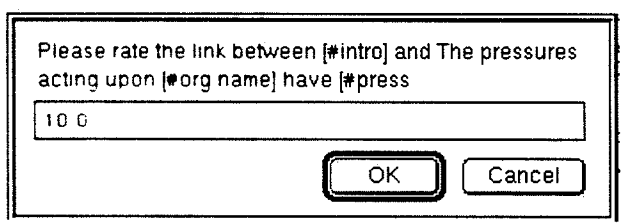
SaGa allows the formula or logical links to be used in any order.



Display 1: Initial display showing the list of snippets and embedded variables.

Building Links

The author builds the link by clicking on the item to be the "head" of the link and then, in turn, clicking on the items to form the "tail". As each tail item is selected, the following prompt calls for the link information from the author.



The response typed in this prompt determines the type of link that is formed. For example, if a number (0 - 10) is typed then the value is linked to the slot with that relative strength. This strength could be a function of the plausibility that a link exists. If an operator (+, -, *, /) is typed then a formula linking the selected values is formed. If a letter is typed then a logical link is formed, with the letter (A, I, E) representing the type of logical rule (conjunction, inclusive disjunction, exclusive disjunction, respectively).

The author shows the variables in their place in the snippets by typing [#short name]. The variables with text values are repeated later in the list of snippets, followed by their alternative text values (as for [#press.action] in the example given in Display 1).

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important when designing sagas for use by managers trying to discover the concepts determining systems behaviour.

Building a Script

A script is a sequence of scenes or snippets that will be translated into the text of the final saga. ' author builds the script by clicking on the "Build script" button and then simply selecting the snipp or slots in the order in which they are to appear in the final scenario. These selections should made such that the scenes are in a sensible, coherent order, forming a realistic scenario.

Using SaGa to Showing Scenarios for Planning

The steps for generating a scenario after the links and scripts have been formed are:

a. Select the scene that is relevant for the saga. This action calls up the script for t scene.

b. Provide the input values.

c. Decide how the values will be selected from lists (randomly, maximum likeliho worst impact).

d. Run SaGa to produce a description of the consequences of choosing the values.

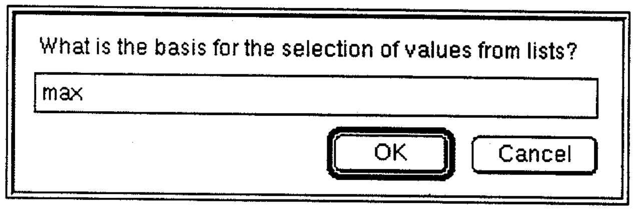
e. Use the resultant saga as a focus for discussion about what should be done to produ a better set of consequences.

If the variable has numeric or logical values, because it is to be used as input in a formula, then values are shown in the Input field, as shown in the example given in Display 2.

It is possible to build a set of input values, in separate columns in the Input field. In that case, scenarios can be built for each column of values in turn, so showing "what-if" effects of the differ values.

Insertion of Values

The following prompt occurs after the author clicks the "See scenario".

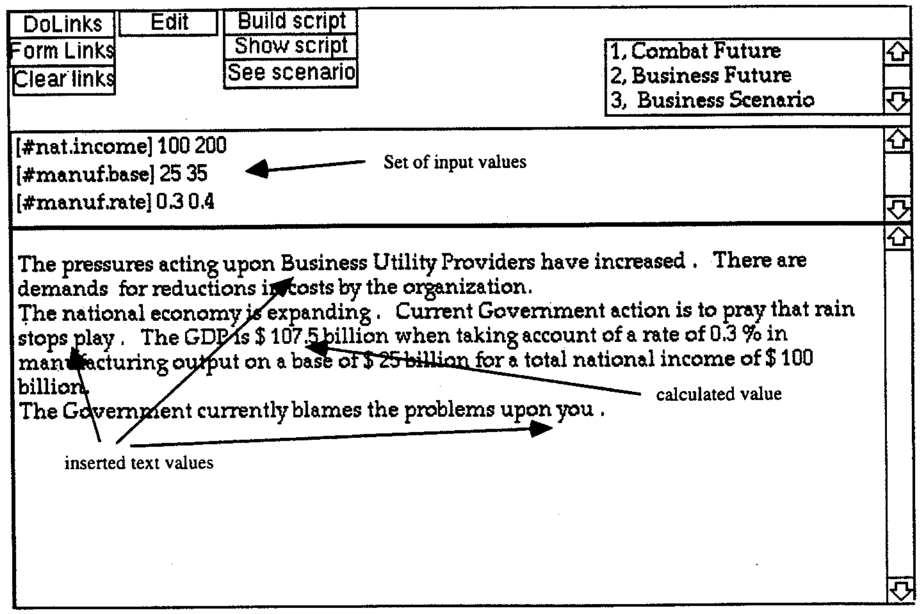


The response typed in the prompt box determines how values are inserted in the slots. For examp if "max" is typed, then SaGa will use that value in the list associated with each slot that has t maximum link strength. If "random" is typed, then SaGa selects a value randomly from the list values linked to each slot.

SaGa can produce a cascade of linked values. The value selected in one list can trigger which o list of values in another list is selected, according to the nature of the links between the variab "owning" the lists.

Resultant Scenario

The scenario will be produced, as follows, after the "See scenario" button is selected. The scena has replaced all the slots with either some text from a list or the results of a formula.



Display 2: Resultant Scenario

Applications of SaGa

SaGa can be used on an aide to simulate complex organizational behaviour so that the users can see the consequences of taking various actions. Managers can determine which set of input values to use and SaGa will write a story that describes the implications of these choices.

Scenarios can be produced using whichever values authors judge are most likely or most worrisome. The results of running SaGa can be shown to managers in order to provoke their ideas or judgements about what should be done to prepare for the scenario.

It is possible to use SaGa in reverse - as a diagnostic tool. The combinations of variables are altered until the scenario describes the symptoms. The combination that produced the symptoms becomes the diagnosis.

SaGa and Other Scenario Software

SaGa is most related to the *IThink*, *SimView*, and *VENSIM*. Systems Dynamics tools. These packages simulate or model complex behaviour, representing the effects in animated graphical form. SaGa can act as a verbal front-end to such Systems Dynamics models. Once the simulation has been run, then the results can be fed into SaGa and used to produce a verbal description of the outcomes. Of course, SaGa provides more scene-setting information that is suited for building mental models or sharing visions.

There are software packages for preparing scenarios, such as BASICS or INTERAX [39] and SMIC-Prob Expert [40] for determining cross-impact matrices. These packages do not seem to be able to build models or to represent different scenarios for different scenes.

The Decision Task Analysis Tool[41], as far as can be seen from the available description, has a basic structure and functions that are similar to those of SaGa. Relationships between decision objects can be used to build a dictionary of links, which can be used to form a cognitive map for validation

39 Huss and Honton (1987)
40 Godet (1991, 1993)
41 Saxena (1993)

purposes. However, this Tool is intended to acquire knowledge about decision-making behaviou with short snippets that elicit such behaviour from experts, rather than to model the future.

Simulations such as *SimCity*[42] can show very graphically what happens when traffic forms grid-lock or pollution becomes rampant. For such cases, SaGa would produce a newspaper that summarize progress[43].

The ability to insert variables within a common framework is not unique to SaGa. Many authorin languages provide this ability[44]. However, these packages usually allow only simple insertions c single variables. SaGa enables more complex sets of variables to be interrelated, in formulae or i decision tables.

Examples of the Use of Saga

Several activities using SaGa are underway at the moment. The results from these activities are nc yet available.

One major activity involves preparing a future for the Australian Army. This future will be used t determine the requirements for Army's Information Management plan and for its force capabilities.

Two versions of SaGa are in use now. The first version[45] is being used to build a possible "Day i the Life" of several types of Army managers, to gather reactions and, hence, priorities fo requirements that led to the building of these scenarios. The version of SaGa that is described in thi paper is being used to build three futures for Army, to see what are the common, 'surprise-free capabilities that will be needed. Later, Systems Dynamics models will then be used to determine th resources that should be allocated to functional areas to ensure that these capabilities can be achieved

Future for Saga

SaGa is still being developed. The different members of the SaGa family of tools are being combine into an integrated planning support system. Refinements are being made in the use of logical links A more attractive user interface is being considered. Additional features are being added to SaGa including the ability for managers to "issue commands" (by typing in text) and in effect altering th underlying model, in order to see what would be the implications of these changes.

Above all, there is a need to use SaGa in a wide variety of circumstances. These experiences ar needed to see what more should be added to its functions. It would be interesting to see whether th "generic models" developed in the Sloan School or provided with IThink can be developed for us with SaGa.

However, once these developments have been made, SaGa should provide a useful extension to th use of Systems Dynamics models in enhancing managerial performance in the learning organization.

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42 *SimCity* and *SimCity 2000*, produced by Maxis, simulate of the development of a city over time, according to decisions the player makes about how to spend funds.

43 SimCity 2000 does provide a newspaper of this interactive nature but it consists of random snippets joined together from a random combination of variables, interspersed with some verbal descriptions of key indicators.

44 see, for example, *Authorware Professional* or *Hypercard* presentations of mathematical problems

45 The use of SaGa to gather requirements for future systems is described in Lewis (1994). There is not enough room to describe it here.

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