DAMAS: an Integrated Business Modelling Information System to Support Management Enterprise Decisions

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Abstract: DAMAS aims at building a decision support system based on the integration of legacy data repositories and system dynamics modelling tools. The latter are used to simulate the behaviour of different business areas, such as marketing, finance, production, etc. Moreover, an enterprise-wide, company-specific model, integrating the aforementioned areas, is being built. The main target is wine production industry. Nevertheless, the DAMAS consortium is pursuing the applicability of the proposed approach to other industrial sectors. DAMAS features a business object architecture, encapsulating legacy repositories, as well as business intelligence and common functions. Managers are provided with a high-level dashboard which co-ordinates, controls and monitors the underlying business objects.

1. GENERIC PROBLEMS IN DECISION SUPPORT SYSTEMS

Still today the majority of software systems supporting every-day work in business company, are conceptually of "metabolic" type, i.e., these systems are procedural-minded: they use a huge amount of data to produce, mainly through aggregation procedures, *documents* (e.g., invoices and orders) rather than *information*. Even when a company information system of this type is well designed, top managers do not receive much information: usually aggregated data and statistical analysis derived as by-products of the main information management activity. Moreover, each of these sets of data typically concerns one specific area of company, i.e.; no view concerning the whole enterprise is provided.

If in the past years it was commonly accepted that the strategic decision making process of a company could be based on a "*sum of elements*" view, today the increasing competitiveness of the world-wide market is demanding for a *Systemic Approach*. The corporate management, which has the aim of controlling a complex system (made of relatively autonomous, though continuously interacting sub-systems), cannot be effectively supported by the views of single sub-systems. In fact, even the management of a specific department should analyse the effects of its decisions over the whole company, since optimising the behaviour of single departments does not generally result in maximising the efficiency of the whole organisation.

In particular, two essential concept time (dynamic vision) and feedback reactions must be taken into account. Considering these factors allows the decision-maker to evaluate the potential consequences of a decision, in both the areas of competence and in all other business areas including external environment.

2. DECISION PROBLEMS IN WINE INDUSTRY

Competition is constantly growing in the wine production industry, especially because of the increase of high-quality producers: traditional European wine producers have been recently joined by producers from North America (particularly California), Australia, New Zealand, South Africa and South American countries.

As a result of this situation, wine companies are looking not only for innovative production processes, but also for effective and reliable management techniques. However, increasing efficiency in the wine industry is not easy, because of the relative complexity of wine industry processes. For example:

- Vintages vary in quality and quantity; crop features depend on the weather and on factors not entirely understood.
- The optimal allocation of crop from different vineyards to different factories is a complex function of capacities and maturation rates.
- Wine production involves lengthy delays, forcing the winemaker to decide on production volumes approximately 18 months before the product is released to the market.
- Demand for a vintage is very difficult to judge, being dependent on consumer taste and market perception.

As a result of this complexity, managers need support tools to understand the influences on their business and the long-term effects of their decisions. System Dynamics models is a powerful tool supporting managers in this task. However, given the non-technical background of most managers in this industry, part of the challenge is to make the required technology accessible to those who must use it.

3. THE ROLE OF SYSTEM DYNAMICS

The System Dynamics methodology was originally designed to model the behaviour of complex systems over time. It does so by representing the processes, structure, strategies and information flows. A definition (Wolstenholme 1990) of the method can be stated as follows:

> *"A rigorous method for qualitative description, exploration and analysis of complex systems in term of their processes, information, organisational boundaries and strategies; which facilitates quantitative simulation modelling and analysis for the design of system structure and control."*

System Dynamics (SD) is a methodology that enables decision-makers to better understand problems as well as the structure of systems to be managed. In fact, it makes possible the identification of a limited number of *master variables* (company *levers*) on which decision-makers have to focus their attention. Moreover, it helps to reach a homogeneous level of aggregation among variables belonging to different functional models, thus achieving an integrated view of problems and, consequently, an inter-functional perspective embracing different business areas.

3.1 What is System Dynamics

System Dynamics models are actually systems of differential equations, such as:

$$L(t) = L(t-\Delta t) + (R_{in}(t-\Delta t) - R_{out}(t-\Delta t))\,\Delta t$$

$$L(t_0) = K$$

$$R_{in}(t) = f(R_x(t), \dots R_y(t))$$

Usually it is not possible to find analytical solutions, because equations that describe real systems are generally non-linear. However, it is possible to simulate the behaviour of a system described by SD equations, starting from the known initial status (e.g., in the equations above the value of L at the initial time t_0 is K) and computing the value of variables at time $t_0+\Delta t$, then at $t_0+2\Delta t$, etc.

Provided that equations represent correctly the nature of the system, and that Δt is chosen small enough to capture the dynamics of the system, the simulation actually represents the behaviour of the modelled system. By the way, there are several commercial computer programs that support SD model editing and simulation.

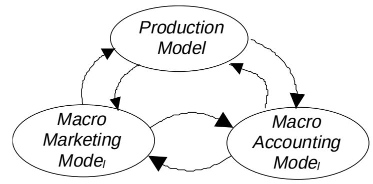
Of course, models generally represent dependencies from "external" variables, whose values in the whole simulation period are supposed known in advance. These variables typically represent "scenarios" representing phenomena not depending on the system being modelled. For instance, the arrival of grapes at a wine production site depends mainly on weather. Decisions concerning the capacity of the production plant should thus be based on the simulation of several possible arrival scenarios.

3.2 System Dynamics in DAMAS

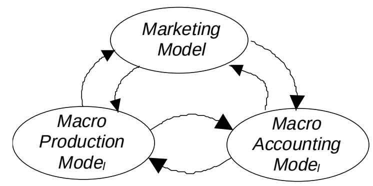
In DAMAS the role of System Dynamics modelling is crucial. Each business area is analysed according to SD methodology, and the feedback influences with main variables of other areas are explicitly represented.

The architecture of different business area models (namely Production, Marketing and Accounting) is presented in the *Figure 1*.

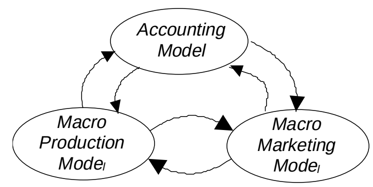
Two different level models are developed for each area: a *detailed* model which takes into account all the interactions among variables of interest to the specific business area, and an *aggregate (or macro)* model taking into account variables which mainly influence other areas. This architecture preserves the detailed view at the business area level without loosing the overall company systemic scenario.



Production Business Area Model



Marketing Business Area Model



Accounting Business Area Model

Figure 1. Different business area models.

4. THE DAMAS PROJECT

The DAMAS (DAshboard MAnager System) project is partly supported by the European Union in the fourth framework program (ESPRIT Project N° 25441). The DAMAS Consortium includes four software developer companies (HELP S.p.A. and CEFRIEL from Italy, HVR Consulting Services Ltd. from England and K-Net S.A. from Greece) and two user wine companies (Casa vinicola di Duca di Salaparuta from Italy and John Boutari & Son Wineries S.A. from Greece.

The objective of DAMAS is *to assist European wine producers to make better operational and strategic decisions by understanding the dynamics of their businesses.*

DAMAS is pursuing its objective by means of the following actions:

1) Developing dynamic models of the key business processes in the wine industry. For this purpose we are exploiting the

experience of wine business managers: two important wine producers (Corvo from Italy and Boutaris from Greece) are acting as users in the DAMAS consortium. Models are being developed and tested using a commercial tool (namely Powersim).

2) Developing "Business objects" technology. Business objects encapsulate in an object-oriented fashion the business knowledge. They use the services provided by databases, by tools supporting system dynamics modelling, or by other sources (such as the WWW) in order to provide a relatively simple interface for the definition of business tasks. Business objects rely on a Business Objects Architecture (BOA) which defines at a top level business intelligence objects and at a lowest level software components.
3) Developing a management dashboard. Managers interact with the dashboard, which assists them in performing business tasks (which are defined in terms of business objects). Actually tasks hide BOs from the user interface (which is thus independent from the BOs) and from the user (who does not need to know BO details).

In particular, DAMAS aims at providing an integrated view of the data concerning the organisation, and the possibility to simulate the behaviour of the whole organisation in different scenarios. Thus, the integration with tools supporting system dynamics modelling is the main focus of the integration with DAMAS business object layer.

4.1 The Architecture of DAMAS

The architecture of the system is schematically described in *Figure 2*.

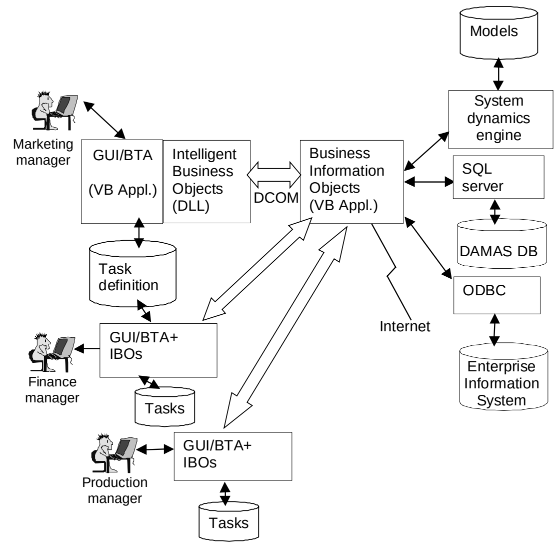


Figure 2. System architecture and GUI/task assistant in it.

4.2 The Business Object Architecture (BOA)

The BOA is the link technology between the system dynamics models and a task oriented information system that can be easily used by managers. It employs "active simulation". We termed it active, because comparing with the usual simulation techniques it uses for its modelling the theory of business objects (Taylor, 1995) and not entities or events. Furthermore, instead of the mathematical approximations made with the other simulation techniques it uses data obtained from the property history of the domain business objects. Finally, “active simulation” offers the capability to use both real time simulation driven by workflow and non-real time simulation driven by a scheduler.

The advantages of “active simulation” over conventional techniques come from the above distinctions. Because it uses business objects to model the problem domain, enables for the creation of flexible and adaptive information systems. The use of the property history of the business objects to capture time-oriented variables, like for example the delivery time of a truck, provides a more reliable way to model these variables than the mathematical approximations made with the various statistical distributions. Finally, the workflow driven simulation enables the manager to instantiate new business objects to the problem domain and examine their behaviour by monitoring their properties.

The BOA includes business objects that, based on the D. Taylor framework (Taylor, 1995), are divided into three categories:

Organisation objects, that co-operate to complete business processes, like purchasing, manufacturing, bottling etc.

Process objects, that either correspond to documents which flow within the organisation or record information, which are vital about a process. Sample process objects are order, invoice etc.

Resource objects, which correspond to physical resources (like employee, grapes, must etc.) used to keep the organisation going.

As an example, consider the first stage in the production of wine, i.e., the removal of the attached twigs from the grapes. Grapes arrive in cartons or trucks in the hoppers, which feed a de-rasping machine. The model uses the capacity of the combined output of the hoppers and de-raspers as a property of the de-rasper business object (*Figure 3*).

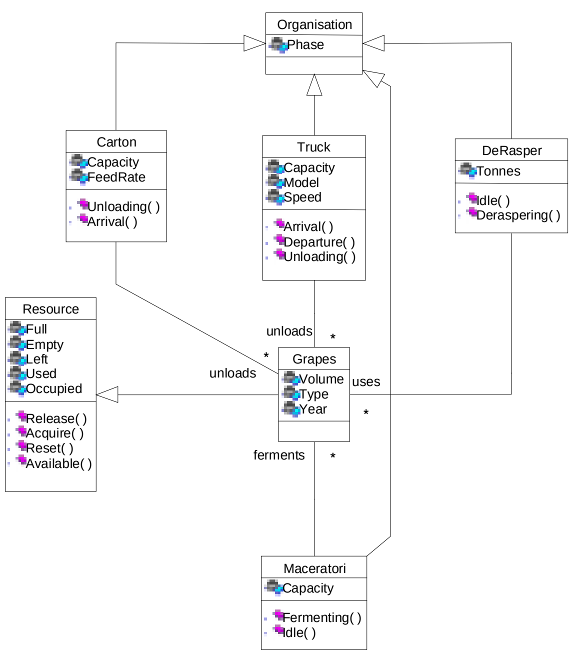


Figure 3. Hoppering and de-rasping.

4.3 The Business Task Assistant (BTA)

The management dashboard is conceptually composed of two elements: the graphic user interface (GUI) and the business task assistant. In the rest of the paper dashboard and BTA are used as synonymous.

The goal of the management dashboard is to assist managers (possibly having little experience in using computers) to obtain the information they need for dynamic decision making at the corporate strategy level as well as at the operational level. In other words, the dashboard helps managers in correctly performing business tasks. Business tasks are implemented through collections of "applications" that are run and controlled by means of the dashboard.

From a functional point of view, the objective of DAMAS is to provide the user (i.e., top/medium management) with a tool that can assist managers in the following activities:

- Exploitation of results provided by the task(s) to support both short and long term planning.
- Selection and (interactive) execution of tasks. Conceptually a task can contain two categories of components: data items (that enable to display and/or edit data), and activities (i.e. data retrieval, simulation execution, etc.). Tasks can be executed iteratively, in order to evaluate the behaviour of the whole organisation in different scenarios.
- Definition or modification of tasks. Actually this operation requires knowledge of the BOs, thus it is generally performed by technical people according to managers' specifications.

The BTA is a tool responsible for initialising, starting, controlling and monitoring management task execution, and for managing information using business objects.

A business task may be a decision to be taken, an assessment to be carried out or a monitoring action within the business of wine production. The BTA allows users to define procedures involving business objects to carry out specific finalised business tasks. BOs belong to the library of business objects provided by DAMAS or can be developed by DAMAS users according to their specific needs. As an example, let us consider the task shown in the following picture.

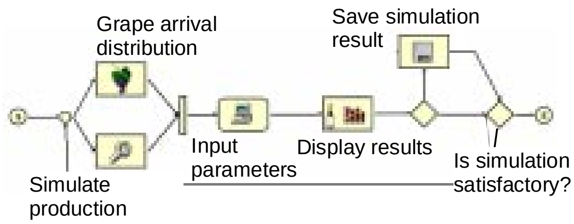


Figure 4. A task representation.

This task deals with the simulation of different scenarios concerning the maceration of grapes. The user is asked to provide a hypothetical distribution in time of grape arrivals, and to set the parameters that describe macerators (default values will be shown by the interface). Here the hypothesis is that the rest of the model's parameters are kept constant, in order to study only the influence of grape arrival distribution on maceration, given a specific configuration of macerators. When both sets of data have been input, the model is simulated. Upon completion of the simulation, results are displayed. Then the user can decide whether to save the results and whether to terminate the task or to go back to the data input and repeat the simulation.

The goal of this task is to determine if reasonable grape arrival distributions could cause the macerators' capacity to become a bottleneck for the system.

Note that data input are described as parallel activities, indicating that the order of data input is not relevant. Parallelisms is indicated by a "fork point" (graphically represented as a small circle). The fact that simulation can be run only when both the data items have been input is indicated by a "thread join" (a vertical bar). The decision point is represented by a big diamond. Arrows transfer control through items. Decision points, Fork points, and Thread joins manage this control, while data items and actions display a real behaviour when they receive control (i.e., when they are activated).

The proposed notation focuses on the activities, which the manager has to carry out, instead that on the nature of the underlying process (e.g., production, as a sequence of de-raspering, fermentation, bottling, etc.). *Figure 4* illustrates the concrete representation of a task.

In addition to the usual help concerning the use of the tool, the management dashboard provides help at two different levels: at the task level, and at the action or data item level.

In both cases, the user receives help/advice of three different kinds:

- Reference documentation provided by the organisation. This is documentation that exists independently from DAMAS, but which the managers could need to consult during task execution.
- Task documentation. This is documentation specifically concerning the task and of the actions and data within the task. Here possible hints and suggestions for the users are also given.
- Business object documentation. This is documentation which comments the business objects involved in the task. This will generally provide relative low-level information (e.g., what is the meaning of a given piece of data).

4.4 System Dynamics Models

From modelling point of view the system (winery) has been analysed through different business areas. Each specific model is developed in detail through a "systemic lens".

There will be also the development of an overall strategic model which integrating all specific area will represent the winery summary model.

Presently the production area is fully analysed, designed and the relative S.D. model is developed. The model is also validated with real data. *Figure 5* illustrates a schematic flow diagram of the production area.

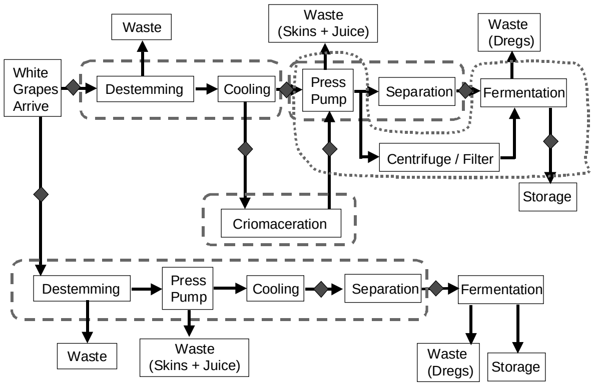


Figure 5. Production Model Schematic flow diagram (White wine process).

The marketing and accounting areas are, up to date, analysed, designed and first versions of the S.D. models are developed. These models are today under final revision and will be soon validated by real data.

Other business areas (personnel, distribution, etc.) are still in the analysis phase and will be integrated in the summary model.

5. STATE OF THE PROJECT

The DAMAS project is more than halfway, as it was started in October 1997 and will end in October 1999.

A prototype is available and is being evaluated by the users in order to validate the DAMAS approach. In fact we have collected several real business task definitions from users and we have built the corresponding tasks in DAMAS. Our collection includes tasks for production planning, personnel planning, financial resource management, liquidity management, marketing sales forecast planning. The latter task is reported in *Figure 6*. We are currently exploring the management of "scenarios". This means that whenever the manager creates a satisfactory scenario (i.e., realistic input conditions that generates satisfactory outputs through simulation), he/she can save it for later use. In particular scenarios will generally be used in comparisons with respect to historical or reference data, search of optimum situations, etc.

In addition, we have defined tasks that do not involve simulation, but rather act as a front end of the company database. For instance, chemical composition of wine samples and the composition of chemical additions can be queried and modified by means of the DAMAS dashboard.

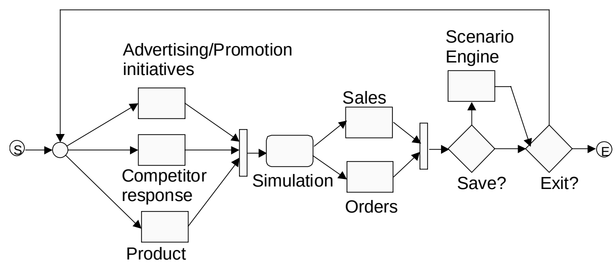


Figure 6. Marketing sales forecast planning task.

6. CONCLUSIONS

There is in process a wine market analysis both to find out the potential users of DAMAS and to find out present use of DSS in this sector. The primary results of this research have confirmed the presence of a poor level of decision making support tools in even leader companies. While this fact encourages us to be optimistic in having a very large potential opportunities for DAMAS, it also fears, the cultural level of winery managers who are not open to use innovative tools.

The very early validation activities with our user partners of consortium are, anyhow, confirming the usefulness of the presented approach.

Interested readers can refer to DAMAS web site www.cefriel.it/~damas for up to date information.

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The DAMAS WWW site, *http://www.cefriel.it/~damas*