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SIMULATION FOR RECURRING DECISIONS

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ABSTRACT

In recent years simulation proved to be a useful technology to support the making of recurring decisions. This paper describes the integrated simulator concept and requirements to make simulation useful for those decisions. First, the differences between onetime decisions and recurring decisions are pointed out. An important difference is that recurring decision-makers don't have assistance from simulation experts to make decisions. Therefore, decision-makers need a solution to be able to use simulation easily. Second, the integrated simulator concept is introduced. This concept can bring simulation to the desk of recurring decision-makers. This has consequences for users, simulation experts and simulation software. Finally, two cases are presented in which the integrated simulator concept proved to be successful.

1 INTRODUCTION

Simulation is a very useful tool to support decision-making. Simulation quantifies the dynamics in complex systems. For strategic, infra-structural and non-recurring decisions, simulation already is a successful and proven technique. In these situations, simulation experts build a model and analyze the situation by changing the model. For recurring decisions, it is too expensive to hire simulation experts to do the analysis, and the decision-makers often have little simulation experience. But simulation is still a useful tool. Therefore, a simulation model that supports recurring decision making has to be very easy to use. What consequences does this requirement have for users, simulation experts and the simulation software?

If the simulation modeling experts do their job right, powerful simulation tools can be brought to the desk of a new group of users: users without any modeling experience. And those simulators can give quantitative insight in the behavior of the system and support (ad hoc) decision making.

Table 1: Differences Between Onetime and Recurring Decisions

Onetime decision	**Recurring decision**
Strategic level of decision	Tactical and operational level of decision
High risk and costs	Medium or low risks and costs
Decision makers at top level; management	Decision makers at medium level; experts
Broad scenarios, different in structure	Narrow scenarios, different in parameters
Input data is very uncertain, with much variability	Input data is rather certain, with little variability
Getting input parameters by extrapolation and expert estimates	Input parameters are available in other systems

2 ONETIME DECISION MAKING VERSUS RECURRING DECISION MAKING

Some decisions have to be made only once. E.g. the decision of building a new production plant or the decision to make or buy half products. Other decisions have a repetitive character, such as determining production plans or checking timetables. Differences between onetime decisions and recurring decisions are summed up in Table 1 and further described below.

2.1 Level of Decision Making

Often, onetime decisions have a long term, strategic impact. Recurring decisions are often made at tactical (medium term) or operational (short term) level.

2.2 Involved Risks and Costs

The risks and costs involved of onetime decisions are usually higher than for recurring decisions. Simulating onetime decisions is relatively cheap compared to the costs of the total decision. The model is an 'insurance'. The risks for recurring decisions are normally lower. The costs of a simulation model relatively high. But a model can be reused every time the decision has to be made, decreasing the 'cost per use'.

2.3 The Hierarchical Level of Decision Makers

The employees making strategic decisions are often situated at the highest hierarchical level of an organization. Tactical decisions are delegated to experts in the field of the decision, at lower levels in the organization. Those experts often have a large knowledge of the primary processes. Both groups of decision makers have little experience in building simulation models or interpreting the output of simulation models.

2.4 The Scope of Scenarios

Decisions are often made by evaluating 'what-if' scenarios. For onetime decisions, scenarios have a broad scope and can be very different in structure. Evaluating these scenarios often requires one simulation model for every scenario. For tactical decisions, scenarios have a more narrow scope, and differences between scenarios are small. The (infra) structure is usually constant. It is often sufficient to use one model and vary the input parameters to decide which scenario is best.

2.5 The Level of Variability

For onetime decisions, many things are uncertain, because the scope is large and the time horizon is long. On the other hand is the uncertainty for tactical and operational decisions relatively small. To make a good, robust decision for strategic decisions the input parameters should vary a lot. For tactical and operational decisions it is often possible to use data that is 100% certain.

2.6 Getting the Input Parameters

For strategic decisions input data are collected by extrapolating historic data, or by using forecasts or estimates made by experts. Getting those data is very difficult and time consuming, because the data is not standardized and scattered. Relevant data for recurring decisions is easier to get, because it is often stored in production applications, such as ERP systems or SCADA systems. The data can be automatically extracted and used in simulation models.

3 CONSEQUENCES

Simulation technology has been useful for decision making. However, to make simulation useful for recurring decisions, it is required that a simulation model can easily access external data and can be used by people without simulation knowledge. The integrated simulator concept is a solution to provide the user with an easy to use decision tool (see Figure 1). For users, life can become easier then. For simulation experts and simulation software, the requirements increase.

3.1 Integrated Simulator Concept

The user interacts with the simulator via a user interface. The user interface consists of three parts. First, the animation to visualize the simulated processes and performance indicators. Second, an input interface to change input parameters and settings. Third, an output interface to view the results of the simulator, to generate graphical reports, and to export the results to spreadsheets, databases, etcetera.

The simulator has a bi-directional interface with external databases for direct access to on line data. Also, the simulator can interact with production applications, such as ERP systems or SCADA systems. The interfaces minimize manual data input. Therefore it saves time and money, and avoids typing errors.

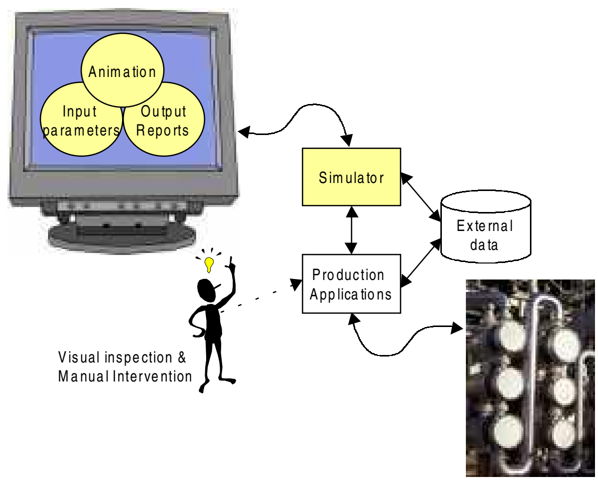

Figure 1: Integrated Simulator Concept

The production applications control the real systems using the input from the simulator, data from the database and, if necessary, manually added information.

3.2 Consequences for Users

If the simulation model is built well, the users will not even know that a discrete event simulator is working behind the user interface. In some ERP systems and Advanced

Planning Systems, simulation is already embedded in the software.

For the user, data collection (one of the hard parts in traditional simulation projects) is becoming easier. By extracting data from external databases, the user doesn't even have to know how the data is collected!

3.3 Consequences for the Simulation Expert

To make a simulation model for recurrent decision support, the simulation expert should know the characteristics of the recurring decision and the user of the simulator. The simulation expert should consider the following.

The user is not a simulation expert! For the user, the user interface is the most important part of the integrated simulator. It is often not necessary to confront the user with the simulation model itself. At least, the users should not have to change the simulation model. The simulation expert should translate the functional requirements into technical specifications.

The simulation model will be integrated in a larger system, e.g. connected to an ERP-system. The simulation expert should therefore know more than the simulation software itself. Other important knowledge areas are specifying the interfaces with other systems, and realizing the complete system. Simulation modeling becomes software engineering!

3.4 Consequences for Simulation Software

Recurring decisions are often made by experts in the field of the decision. Those experts often have a large knowledge of the primary processes, but little experience in building simulation models or in interpreting the output of simulation models. In order to use simulation software to support recurrent decision making the software will need the following functionalities.

3.4.1 Hiding the Model

Users should be able to use simulators without simulation knowledge. The user should not have to change the model. This is possible if user-friendly interfaces can be build, which are hiding the simulation model.

3.4.2 Open to Other Systems and Databases

To minimize user actions and to have consistent and reliable data, most of the input data should be extracted automatically from other databases and transferred to the model. After that the model should run and generate the desired output. The output should than be presented to the user in the desired format and in the desired program (e.g. a report generator, spreadsheet or database).

3.4.3 Using Templates or Libraries

Another possibility is the use of high level templates, dedicated for the decision that has to be made. Those templates require little knowledge of the underlying simulation language, and can be easily used, also by people with little simulation experience. See also Teunisse and Pater (1997) for the advantages of templates in simulation projects.

For example, supply chain templates can model the flow of goods from raw material production via distribution centers to the outlets. Incontrol Business Engineers created "CLoSE" – Chain Logistics Simulation Environment. This template contains many standard stock control rules. These rules can be found in logistic literature, such as Bertrand, Wortmann, and Wijngaard (1990). Building a supply chain model with CLoSE requires little knowledge of the underlying simulation language. Users can concentrate on the problem itself.

3.4.4 Automatic Model Generation

A promising new development is automatic model generation. Information stored in databases is translated into a simulation model, without human intervention. The model can be built even faster, if custom made templates are used. This can be very useful in areas where infrastructure is evaluated at a continuous basis. E.g. the Dutch rail infrastructure provider RAILNED evaluates the capacity of the infrastructure in relation to the timetables of rail users. A feasibility and sensitivity check of the timetable is performed by simulation. The complete simulation model is automatically generated without human intervention. See also Bouwman (2000).

3.4.5 Simulation via Internet

In the near future, Internet/intranet accessibility can also become necessary for certain applications. For example, commercial managers at various places can evaluate the production plan if new orders are accepted, and see when those orders can be delivered to the customer.

4 SIMULATION IN RECURRING SITUATIONS IN PRACTICE

Simulation for recurring situations can be useful in complex situations. Those situations are often too difficult to handle with optimization tools, and controlling manually is very time consuming or even impossible. Other situations are situations with a high level of uncertainty.

Below we will describe two cases where simulation models were built to support recurring decision-making.

4.1 Example: Raw Material Supply

A European production company is using raw materials (vegetable oil), which have to be shipped from Southeast Asia. Due to the use of standard trading contracts, the arrival date of ships in Europe is uncertain. Figure 2 shows the variability in the amount of shipped materials in Asia and in the amount of materials arrived in Europe.

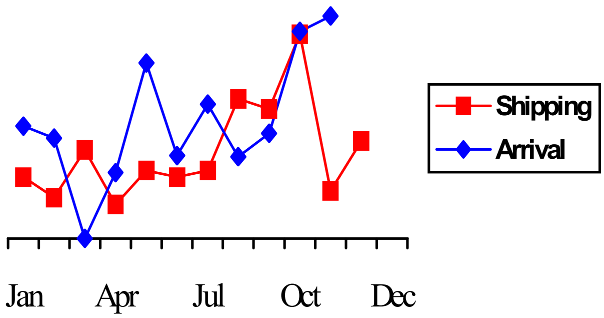

Figure 2: Variability in Shipping and Arrival Dates

Out of stock situations are very expensive. Therefore, a large amount of oil is kept on stock in Europe, to create a buffer for the production facilities in Europe.

To reduce the stock level in Europe, a simulator was built to get insight in the behavior of the stock levels, and to ensure that the risk of out of stock situations was kept as low as possible.

The simulator was hidden behind a spreadsheet interface, in which the users can vary the input parameters, such as the expected production levels for the next months. The output generated by the simulator is graphically presented in a spreadsheet.

After the first experience with the simulator, the decision makers were confident that a significant reduction of target stock levels would not lead to out of stock situations. Thus, they decided to reduce the target stock levels. The simulator is reusable, because all the relevant input parameters can be changed in the spreadsheet input interface. Therefore, the target stock levels can be adjusted to the forecasts of the production sites for the next months.

4.2 Example: Production Planning

One of the elements of production planning is scheduling. Simulation based scheduling has been used for several years in some standard scheduling solutions, such as Preactor (Trademark of Preactor Inc.). For more complex situations, these standard scheduling solutions can not always cope with all the planning details. In those situations, custom built simulators can support the production planners to verify and evaluate production plans.

Especially in the semi process industry the production infrastructure is complex. Because of the complexity, decision support tools are necessary to help the planners to deliver a robust production plan. The tools should also optimize the utilization of the production equipment, because the equipment is often very expensive.

A producer in the process industry has a complex pipe infrastructure (see figure 3). A simulator was built for them to help them make decisions about investments in the infrastructure. Because the production volume is growing, this decision is made on a regular basis.

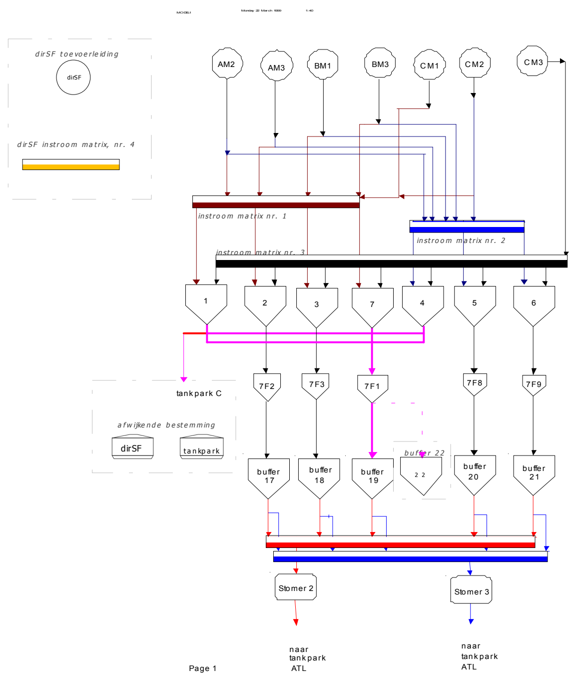

Figure 3: Complex Infrastructure for a Refinery

4.2.1 Background

Some special characteristics of this company are:

- multi-product refinery;
- uncertain machine times;
- uncertain arrival times of supplies;
- more products on one production line;
- a large variety of production control-rules.

4.2.2 Objective

The company aimed to study the production process in order to:

- determine bottlenecks;
- suggest alternative layouts;
- compute and compare the effects of these alternatives.

4.2.3 Simulation Model

A simulation template (simulator) was built that:

- could import relevant planning data;
- could be used repeatedly;
- could be used by employees for extensive experimentation.

The simulation model consisted of an input application, a simulation engine, and an output application. The user is capable to change input parameters (such as the number of machines, production plan and production times). The simulation engine calculates the results and these are visualised in the output application.

Animation is used to validate the simulation model and to present the simulator to the management.

The organisation has formed improvement-teams with employees, each with their own speciality. The teams are working on improvement of (among other things) the logistic performance of the factory. Improvement ideas are evaluated with the simulator.

4.2.4 Results

By extensive experimentation with the simulator:

- more insight in the current production process was obtained;
- bottlenecks were determined and suggestions for infrastructural changes were developed;
- quantitative results for the effects of these changes on production and capacity performances were provided and compared.

These results in turn led to support for final decision making of these infrastructural changes. As a next step, in the near future the simulator will be used for operational what-if analysis and production planning.

5 CONCLUSIONS

Two projects have proven that simulation can also be a very useful technique to support recurring decision making. Recurring decisions have different characteristics than onetime decisions. Important is that the simulation model is easy to use, has a user-friendly interface and is connected to other systems. These are the main characteristics of the integrated simulator concept. Building a simulator is therefore more than building a model. Simulation becomes software engineering. Simulation software suppliers should known what the requirements are to support recurring decision-making. Important requirements are the possibility to link with other software ('open'), the possibility to create templates or libraries, automatic model generating, and in the near future Internet simulation.

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