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SHORT-TERM SIMULATION: BRIDGING THE GAP BETWEEN OPERATIONAL CONTROL AND STRATEGIC DECISION MAKING

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Abstract

An increasing number of enterprise information systems uses modern software tools such as workflow management systems and enterprise resource planning systems to support the control, co-ordination, monitoring, and execution of business processes. As a result, these enterprise information systems have knowledge of the business processes, of the current state of each process, and of historical data. This knowledge enables the application of a special form of decision support: *short-term simulation*. Short-term simulation exploits the information that is available: decisions that affect the business processes in the near future can be evaluated without the need for any additional modelling efforts. The structured storage of information in an enterprise system enables a relatively simple creation of a simulation model. This paper introduces short-term simulation by showing the relations and differences with strategic simulation and operational control. The data that may be used for this kind of decision support is outlined. Also, a simulation architecture - which has been applied in practice - is presented.

Key words: discrete event simulation, operational control, decision support, business process analysis, enterprise systems, workflow management systems.

Introduction

Traditionally, simulation of business processes is used to support strategic decision making. In this case, simulation is used as a tool to analyse long-term effects of certain decisions ([1,2,3]). Simulation is rarely used for management control and operational control, because building a simulation model takes too much time to evaluate short-term effects. However, an increasing number of business processes is executed under the control of a *Workflow Management* (WFM) system ([4,5,6,7]) or an *Enterprise Resource Planning* (ERP) system ([2,8,9]). These systems have an up-to-date description of the structure of the business process and its current state. This information can be used to generate a simulation model which can be used to evaluate the short-term effects of a decision *without* building a simulation model from scratch.

Both WFM and ERP systems are used to support the control, co-ordination, monitoring, and execution of business processes. WFM systems are mainly used for administrative processes. At the moment more than 200 WFM systems are available. ERP systems are mainly used by enterprises that produce and/or distribute products. SAP R/3 ([8]) and BAAN IV ([9]) are two of the leading ERP systems. Both WFM and ERP systems have a so-called workflow engine. The workflow engine decides which tasks need to be executed, in what order, and by whom. The workflow engine uses process definitions, resource classifications, and rules for resource allocation to make the proper decision. A process definition describes each of the tasks and the order in which these tasks need to be executed. A resource classification describes the types of resources that are available. For each task it is specified what type of resource is needed. This information combined with the rules for resource allocation is used by the workflow engine to map work onto resources.

Simulation tools also have an engine. This simulation engine is used to control the handling of events in a simulation. There are many similarities between a simulation engine and a workflow engine. They both take care of the operational control and require similar input data. However, a workflow engine interacts with the real world and a simulation engine assumes certain things about the real world (e.g. the duration of tasks and the availability of resources). Because of the similarities between the functionality of a workflow engine and the functionality of a simulation engine, the use of simulation for decision support in environments where WFM or ERP systems are used is attractive. Several WFM and ERP systems support simulation or provide a gateway to existing simulation tools. These simulation facilities support strategic decision making. However, in enterprises where WFM or ERP systems are used there is also a need for decision support for management control and operational control. The traditional approach towards simulation does not work for this purpose, because it focuses on strategic decisions with long-term effects.

In this paper we advocate the use of *short-term simulation*. One can think of short-term simulation as a quick look in the near future, i.e., a kind of “fast forward” button. By pushing this button, it is possible to see what happens if the current situation is extrapolated. It is also possible to see the effect of certain decisions (e.g. hiring additional employees or renounce new orders) in the near future. In this way, short-term simulation becomes a powerful tool for management control and operation control.

The remainder of this paper is organised as follows. In the next section we will discuss the most important characteristics of a short-term simulation in the context of other, more traditional types of simulation. Next, we will outline the different types of data that can be used in a simulation. A separate section is dedicated to the relevance of short-term simulation, including a small example. After this section we will discuss an architecture that integrates the notions of simulation data and those of an enterprise system. We end this paper with our conclusions.

Context

The type of simulation considered in this paper is discrete event simulation, i.e. the state in the simulation model changes at discrete points in time that are not necessarily equidistant. In literature on discrete event simulation (cf. [10,11,12,13,14,15]), often two types of simulation models are considered: *terminating* and *non-terminating*. In a non-terminating model the model will soldier on for a long as we care to run the simulation. In a terminating model, there is a clear start and end of the simulation. A non-terminating model continues indefinitely and the long term behaviour is usually steady state. Therefore, non-terminating models are mainly used to analyse the steady-state behaviour of the modelled process. For terminating models, the transient behaviour is as least as important. Transient behaviour in the form of an initial transient is nearly always present when a simulation starts.

In this paper we distinguish between *short-term* and *long-term simulation*. In both cases, the model is in principle non-terminating. But there are differences as well, as a short-term simulation focuses on short-term, operational effects within a business process rather than long-term, strategic effects. These simulation differences are illustrated in Figure 1.

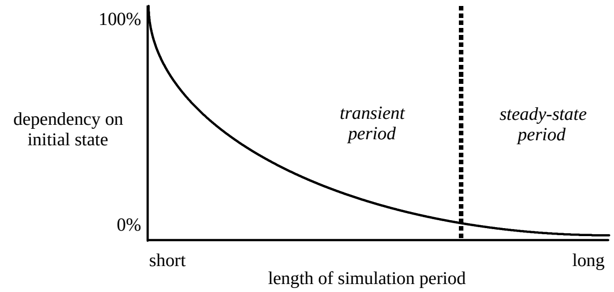

Figure 1: In most cases, the impact of the initial state on performance measures decreases when time passes.

First of all, the notion of an initial state, reflecting the actual current state of the business process, is essential for a short-term simulation. This is because we are particularly interested in the initial transient. The effects we are investigating rely heavily on the current situation. For example, if there is currently a large amount of work-in-progress, this may seriously affect the processing of new orders in the next few days. This in contrast to a long-term simulation where, in most cases, an artificial initial state is used. The primary focus then is on the steady-state behaviour. The second difference is the simulation period of a short-term simulation, which is comparatively short. After all, the longer the simulation period, the smaller the effect of the initial state. As soon as the influence of the current state wears off, the decision making moves away from the operational level.

Data

We distinguish between two types of data that generally drive a simulation model: (i) data based on random numbers generated from parameterised probability distributions and (ii) trace data generated from the operational system. We roughly identify the application of three types of input data within a simulation:

1. *Historical data*. The simulation is controlled by input sequences of trace data which are based on the dynamics actually observed in the past.
2. *Derived parameters*. Historical data is used to calculate appropriate parameters of probability distributions, i.e., the profile of the dynamics actually observed is used to configure the simulation model.
3. *Estimated parameters*. The parameters of probability distributions are estimated by the analyst. These parameters are not based directly on historical data because these are not available or are intentionally ignored.

Note that WFM and ERP systems collect all kinds of historical data which can either be used as input sequences or to estimate parameters. Based on these three types of input data and the difference between short-term and long-term simulation, we identify the six types of simulation shown in Figure 2.

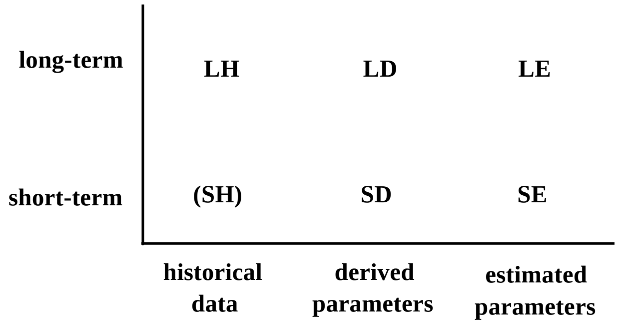

Figure 2: The types of simulation considered in this paper.

In Figure 2 a distinction is made between simulation types that are driven by historical, derived, and estimated data. In practice, a simulation may correspond to a mixture of the types mentioned, e.g. some parameters are estimated and others are based on historical data. There are subtle mixtures possible, depending on the purpose of the simulation. For example, to determine the effectivity of a new process structure, a historical arrival pattern of cases may be used in combination with a new task topology. Figure 2 also displays the division between long term simulations - types LH, LD, or LE - and short-term simulation simulations - types SH, SD and SE. Note that type SH is placed between brackets in Figure 2, because a pure SH simulation is not possible by definition: a short-term simulation starts in the current state and not some state in the past. Type LH (in pure form) is only possible if the simulation starts in the state at the moment the recording of historical data started.

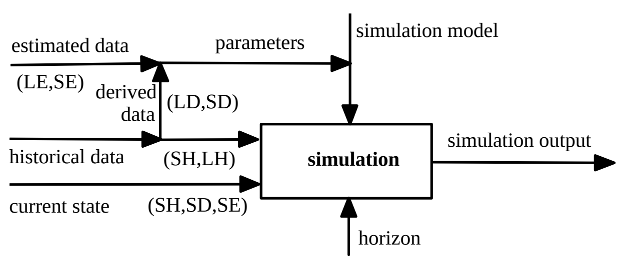

Figure 3:The required input data depends on the simulation type.

Figure 3 shows the relation between the type of simulation and the input of the simulation. The current state is used as initial state of the simulation in case of type SH, SD and SE. Historical data is used directly for simulation experiments of type LH and SH and indirectly for simulation experiments of type LD and SD.

Relevance

From a theoretical point of view, short-term simulation may seem somewhat trivial. However, from a practical and technical point of view this is not the case. Short-term simulations can be an important aid to detect the endangerment of business targets. Imagine, for example, a company that carries out repairs of television sets. It guarantees its clients that repairs will be carried out within 24 hours. An short-term simulation may indicate that given the actual amount of work, new repairs are impossible to complete within 3 days. The manager of this company may decide not to take on new orders for a while, to hire extra resources, or to let his engineers work over time. Another option would be to organise the repair process somewhat differently to buy time. Clients may be asked to pick up their repaired tv-set themselves instead of having it delivered to their houses, for instance. Again, the effects of each of these alternatives can be examined using short-term simulation. More in general, short-term simulation may be used:

1. to spot unbalances between *work* and *resource capacities*, and
2. to examine the effects of counter measures.

Compared to traditional approaches it is interesting to see that existing process definitions (used by the workflow engine) and operational data can be used for a short-term simulation. In this way, the effort needed to design a simulation model and to collect data is reduced considerably.

Architecture

In this section we will present a system architecture that integrates operational control and simulation facilities. Our starting point is the reference model as developed by the Workflow Management Coalition (WfMC) ([1,3]). The WfMC establishes standards for terminology, interoperability, and connectivity for software that enables the automation of business procedures. The reference model of the WfMC distinguishes a workflow engine as a central component with several interfaces to five specific other components of a workflow system. These components are: (i) the process definition tools, (ii) the workflow client applications, (iii) the invoked applications, (iv) other workflow engines, and (v) the administration and monitoring tools. These components are depicted in the lower, right part of Figure 4. The rest of the picture consists of extensions of this model.

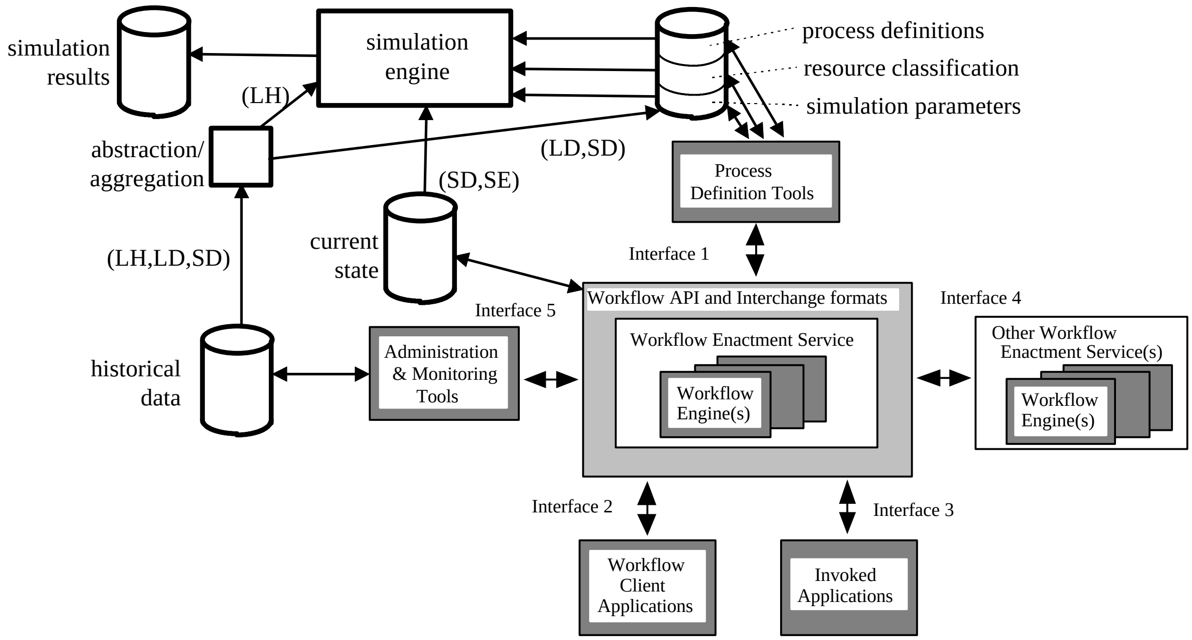

Figure 4: Simulation embedded in the reference model of the WfMC.

Regardless of the type of simulation we would like to perform we need to connect to the process definition tools to collect information on the process definitions, resource classifications, and all kinds of other information. This usually means that some sort of definition or configuration file that is generated by these tools should be concerted into a format that is understandable by the simulation tool. This is a relatively simple exercise. We have practical experience with translations of both ERP (e.g. BAAN) and WFM (e.g. COSA) system definition files into simulation models.

To obtain historical information for the purpose of a simulation a link has to be made with the administration tools. As shown in Figure 4, this type of information is required when we choose to perform a LH, LD, or SD type of simulation. Not every ERP or WFM system is equally well equipped to extract this kind of data using its standard tools. Usually, a direct extraction from the enterprise system database is possible. Depending on the desired level of re-use of historical information, the data may be aggregated. The results may be directly used during simulation, or they can be used to adapt the simulation model as translated from the definition file. The latter is typically applicable when we use historical information to derive simulation parameters.

When we want to perform a short-term simulation we have to tap into the current information an enterprise system uses. This kind of tap is not explicitly foreseen by the WfMC, although it can be compared with the exchange of operational information with other workflow systems (interface 4). As we have argued before, any enterprise system will maintain this kind of information. The trick is rather to locate this information.

We depicted in Figure 4 the simulation engine as the heart of the simulation capabilities. To enable the analysis of the simulation results, the results of the simulation may be stored in a separate component.

We applied this model in practice for a large social security company in the Netherlands. Short-term simulations are used within this company to support resource planning within various types of business processes. In Figure 5 a screen-dump is shown of one of the business processes involved.

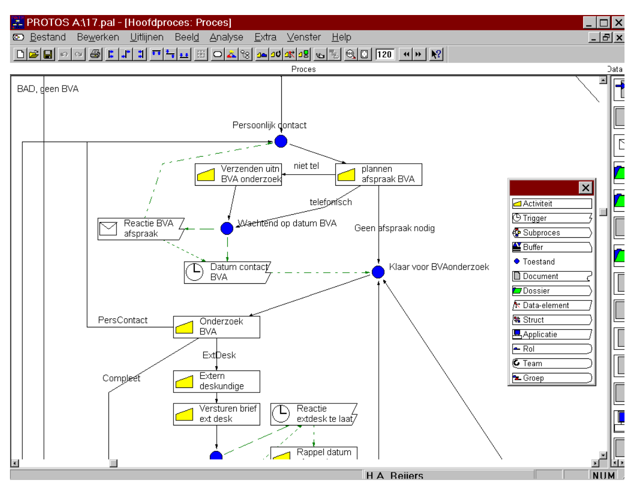

Figure 5: One of the processes supported by short-term-simulation.

The tools used in question were the process-modelling tool Protos ([15]), the workflow management system COSA ([16]) in combination with the case handling system FLOWer ([17]) and the simulation tool ExSpect ([18]). One of the successful ingredients for this integration was the common process notion of these tools in terms of Petri-nets ([4,19]).

Conclusion

In this paper we presented the concept of short-term simulation on basis of information already available in enterprise systems, such as WFM or ERP systems. A short-term simulation can present a "fast-forward" view on a current business process. Its main purpose is to identify imminent unbalances between the work offered to the business process and the resources available. Short-term simulations may also be used to investigate the effects of alternative resource schedules, new policies on accepting work, and BPR scenarios. Although the creation of short-term simulations was possible before, the storage of structured information on the business process in enterprise systems eliminates many of the usual efforts to create a valid simulation model. In addition, the actual state can be downloaded into the simulation model.

We think that short-term simulation offers a valuable form of decision support. The fact that the current state is incorporated allows for the generation of reliable information about the near future. The application of simulation in business environments harmonises with the tendency of enterprise systems to advance beyond operational control facilities. As WFM and ERP tools have reached a reasonable state of maturity, they start to incorporate more and more facilities to analyse and strategically manage the business process. The integrated use of business information with analytical methods like simulation may really boost this development.

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