Proceedings of the 1998 Winter Simulation Conference
D.J. Medeiros, E.F. Watson, J.S. Carson and M.S. Manivannan, eds.

SUPPLY CHAIN SIMULATION WITH LOGSIM-SIMULATOR

Saku Hieta

Nokia Research Center
FIN-00210 Nokia Group, FINLAND

ABSTRACT

Supply chain management has become one of the most important sources of competitive advantage in telecommunication equipment manufacturing during the 1990´s. The key to success in this dynamic business environment is the ability to introduce innovative, customized products with short time-to-market without sacrificing logistical efficiency. Supply chain simulation is a powerful analysis method for evaluating the tradeoffs between product customization and logistical efficiency. Simulation can be used to support decision making in both product design as well as in supply chain design. This paper describes how supply chain simulation has been used in Nokia. The basic elements of the supply chain simulation models developed at Nokia Research Center (NRC) are described and a special purpose simulator, LOGSIM, is introduced. Some experiences of using supply chain simulation in actual business cases are discussed and ideas on the future of supply chain simulation are presented.

1 INTRODUCTION

In the rapidly developing telecommunications industry, the ability to launch new innovative products to the market before competitors is the most important competitive factor for an equipment manufacturer. Short time-to-market has to be achieved without sacrificing profitability, and it is therefore essential that the logistical effects of introducing new products and new operational practices can be evaluated before production is started. Discrete-event simulation has been used in Nokia for several years to analyze the effects of new products on manufacturing line performance, but during the last few years the focus of simulation activities has been extended to logistical issues, covering the whole supply chain from component suppliers to final customers.

The most important use for logistics simulation in Nokia has been the analysis of alternative product structures and alternative inventory and production control methods. In a typical simulation case, a decision on the number of product or subassembly variants is to be made, with inventory carrying cost as one of the dominant factors to be accounted for. In these cases, simulation can be used to evaluate the inventory levels required in order to achieve a given service level target and to perform sensitivity analysis regarding the number of product variants. When new inventory and production control methods are being introduced, simulation can be effectively used to study the overall effects of the modifications on the whole supply chain, rather than limiting the analysis to the local effects in a single manufacturing process or a single buffer.

Logistics simulation models can be built either for one-time projects, to perform the analysis required to support decision making in a specific business case, or to support decision making on an on-going basis, by embedding the model in a special purpose simulator. Section 2 below gives an overview of logistics simulation in general and in Section 3 a logistics simulator, LOGSIM, developed at Nokia Research Center (NRC), is described in more detail.

2 ELEMENTS OF LOGISTICS SIMULATION MODELS

The general structure of a typical supply chain in telecommunications equipment manufacturing is shown in Figure **1** below. The scope of this model has been limited to include only the first-tier suppliers, and distribution portion of the supply chain has been modeled on a very rough level. The basic elements needed for a simulation model of this type of supply chain are: suppliers, buffers, production and assembly processes, customers and material requirements planning (MRP).

Suppliers can be modeled as processes, that receive orders from either MRP or from a component buffer and deliver replenishments to a component buffer with a given delivery time distribution. By using an attribute to indicate the component type, a single supplier element can be used to represent all the suppliers delivering components to a

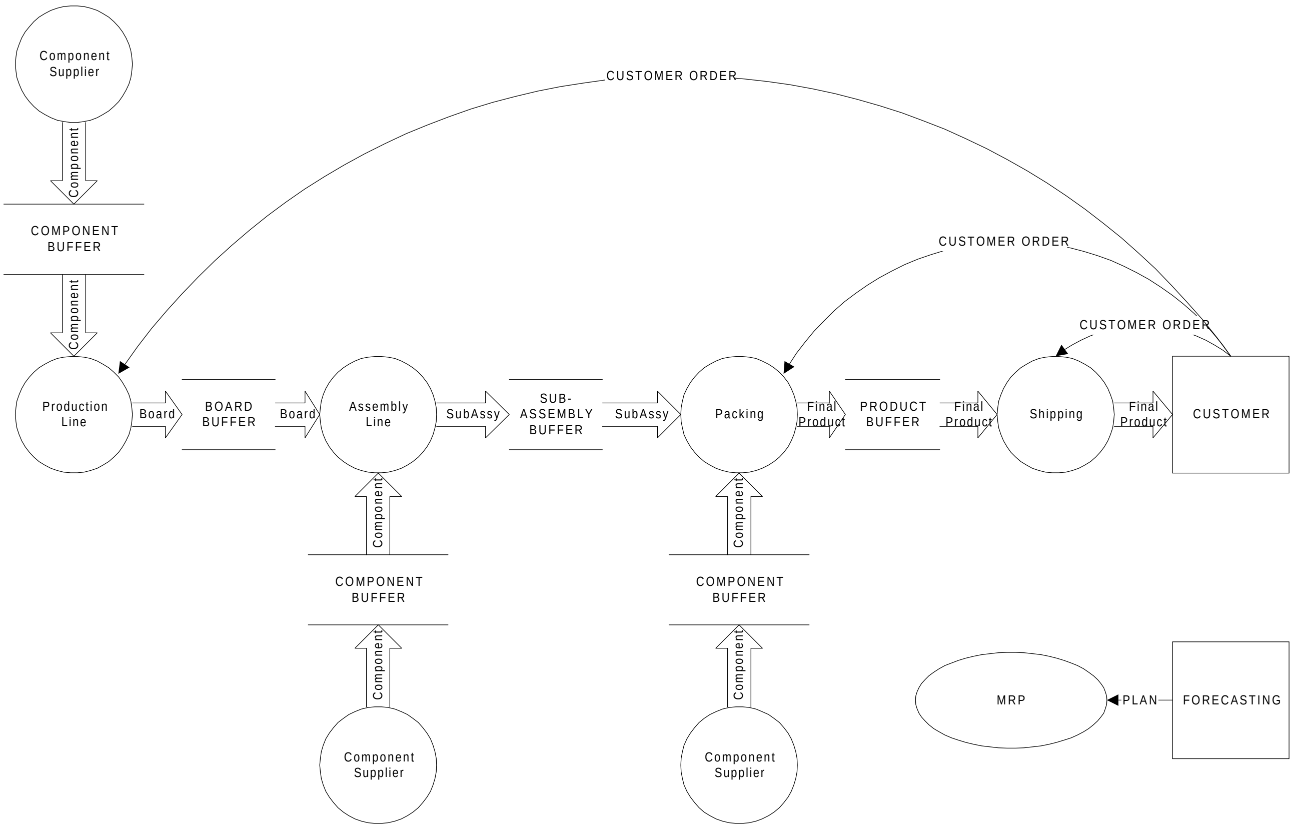

Figure 1: A Supply Chain Model

specific buffer. More detailed supplier models can include parameters for supplier flexibility (i.e. the ability of a supplier to increase production in response to increasing demand) and can be used to evaluate inventory levels required at the supplier.

Buffers are used to represent the various inventories held in the supply chain. Buffer can be easily modeled by using arrays to store the inventory level and other necessary information on each type of material buffered. If information is needed on the time spent in the buffer by individual lots of material, a more detail model can be used. Buffers can be passive, without any inventory control, in which case the preceding process pushes material into the buffer and the subsequent process pulls material from the buffer. Usually inventories are controlled with an inventory control policy, such as order-point method or MRP. In simulation models built at NRC, MRP has been implemented as a separate element (see below), but order-point method and other simple inventory control policies have been embedded into the buffer element.

Production and assembly processes are the points in supply chain where material flows are transformed and merged from components to subassemblies and from subassemblies to final products. In telecommunication equipment manufacturing, examples of production and assembly processes include board assembly in automated SMD lines, manual mechanics assembly and packing. A process is driven by work-orders that can be based on a scheduled production plan, customer orders or internal replenishment orders. A process then pulls the required components from a component buffer and pushes the subassembly or final product to a subsequent buffer. In supply chain analysis, the level of detail required to model a process is usually low, with no need for analysis or visualization of the internal logic of a process. At NRC, processes have often been modeled simply as having a constant capacity and a fixed throughput time. Models of individual production lines and assembly cells have been built separately to study their performance in more detail, using 3D animation and other suitable forms of visualization.

Customers are represented by elements that generate customer orders and receive deliveries. For less detailed analysis, the order generation functionality can be implemented inside the simulation model, with the statistical distributions provided by the simulation software. For more sophisticated demand models, a separate demand generation module can be built and linked to the simulation model. This is the approach followed in the LOGSIM-simulator (see below). The customer element of a simulation model is also used to gather data on customer service parameters, such as delivery times and delivery accuracy.

Material requirements planning (MRP) is still the dominant production and material management method in telecommunication equipment manufacturing, although pull-based methods, such as Kanban, and make-to-order production are gaining ground. Given the computing power of today's PCs, MRP can be used in simulation models with quite realistic product structures. Programming the logic of MRP into a simulation model is not a problem, but the limited data-structures of a simulation software can be a problem.

3 LOGSIM SIMULATOR

The overall structure of the LOGSIM simulator is shown in Figure 2. The simulator consists of four modules: user-interface, order generator, simulation model and report generation. User interface, order generator and report generation modules are implemented with Visual Basic for Applications (VBA 4.0) with Excel 97 as the background application. Excel is a familiar environment for the users of the simulator, which makes the simulator easier to learn and gives the users the ability to define their own reports and to easily prepare presentations from the obtained results. The simulation model has been built with ProModel 4.0, which communicates with Excel through OLE-automation, text files and wk1-files (the format of arrival files in ProModel).

The user interface of LOGSIM provides a well-structured way of setting the input parameters of the simulation model, with an on-line help containing all parameter definitions. There is also a data validation functionality, which ensures that only valid parameters are given as input to the simulation model.

The order generator generates arrival files, with each line of a file presenting a customer order, with a specified arrival time, lotsize and product type. The arrival files are generated based on demand parameters such as monthly sales volumes, forecasting accuracy and lotsize distribution. The pseudo-random number generation function in VBA is used to generate random arrival times and random lotsizes. The approach taken in LOGSIM has been to let the user specify a sales plan explicitly and to generate the customer orders, that follow the plan within the specified forecasting accuracy The explicit sales plan figures given by the user are used for MRP calculations during the simulation, while the generated customer orders represent the actual demand.

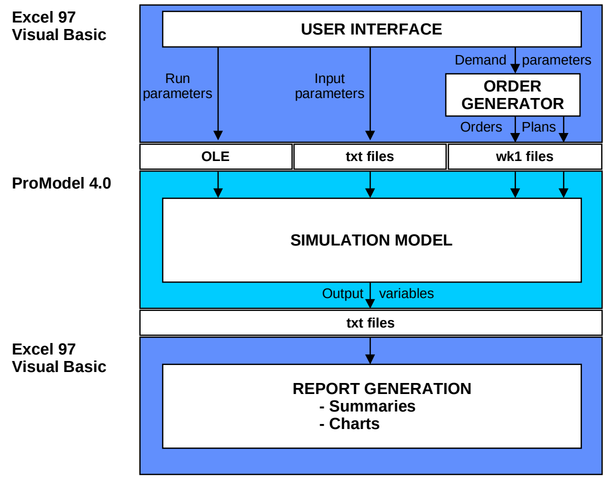

Figure 2: Structure of LOGSIM-simulator

The user interface of LOGSIM provides a well-structured way of setting the input parameters of the simulation model, with an on-line help containing all parameter definitions. There is also a data validation functionality, which ensures that only valid parameters are given as input to the simulation model.

The order generator generates arrival files, with each line of a file presenting a customer order, with a specified arrival time, lotsize and product type. The arrival files are generated based on demand parameters such as monthly sales volumes, forecasting accuracy and lotsize distribution. The pseudo-random number generation function in VBA is used to generate random arrival times and random lotsizes. The approach taken in LOGSIM has been to let the user specify a sales plan explicitly and to generate the customer orders, that follow the plan within the specified forecasting accuracy The explicit sales plan figures given by the user are used for MRP calculations during the simulation, while the generated customer orders represent the actual demand.

The simulation model embedded in LOGSIM includes the basic elements described in the previous section. The number of replications performed for a particular set of input parameters is set by the user, as is the run-length of the replications. Each replication has unique customer orders and a different seed for statistical distributions used in the model (e.g. supplier delivery times).

The report generation module creates a predefined summary report of all the replications as well as detailed reports of individual replications. The basic principle in generating the reports has been to provide all the output data from the simulation run on a transactional basis, with as little averaging as possible. Since all output is provided in Excel worksheets, it is easy for the user to create personalized reports, if necessary.

4 EXPERIENCES FROM LOGISTICS SIMULATION IN NOKIA

Overall, the experiences from using supply chain simulation in Nokia have been very positive. The value of a tool, that enables the decision-makers to analyze inventories and customer service performance explicitly, has been widely recognized in Nokia business units.

There are, however, some special problem areas involved in supply chain simulation. First of all, a basic understanding of the random nature of demand and the supply chain dynamics is needed before a decision-maker can interpret the results given by a simulation. A simulation model itself can be used to demonstrate the basic phenomena, and it is essential that this is done before proceeding to simulation of an actual business case. The complexity of even the most simple real-life situations makes it impossible to interpret simulation results without insight of the system dynamics.

If possible, the simulation results should be presented using the metrics and the form of presentation that is used in standard operational reporting. A familiar form of presentation makes it considerably easier for decision-makers to interpret results.

Building a special purpose simulator that can be used by persons without simulation background is the most efficient way of promoting the use of supply chain simulation inside an organization, provided that the simulator has been well designed and implemented. The underlying simulation model does not have to be state-of-the-art, the emphasis should be on user-interface and reporting capabilities. Once the users have been accustomed to performing simulations and analyzing results, one can develop the underlying simulation model further. Understanding issues such as determining the warm-up time and the reason for making several replications may take time, and it is better to start with a simple model, that enables the users to get familiar with these basic aspects of simulation.

5 DIRECTIONS FOR FURTHER RESEARCH

Although supply chain simulation has already been accepted inside Nokia as a valuable analysis tool, there are several subjects related to supply chain simulation requiring further research. Integration of the LOGSIM simulator with process mapping tools and product costing models is one of the key areas to be considered. Another direction for supply chain simulation in Nokia is the development of modular simulation models that can be easily modified to fit a particular supply chain structure. The key to this kind of modularization is the use of object oriented simulation tools. Web based simulation also offers interesting possibilities for supply chain simulation. By embedding user interface and report generation modules in a browser and order generator and simulation model on a server, a powerful supply chain analysis tool could be brought to practically every desk in an organization.

AUTHOR BIOGRAPHY

SAKU HIETA is a research engineer at Nokia Research Center where he provides consulting in supply chain analysis and simulation. He received MSc degree in applied mathematics at Helsinki University of Technology in 1997 and joined Nokia the same year. His current interests include the use of simulation in the planning and design of supply chains.