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Simulating Availability Outlook for e-Commerce Business of Personal Computer Sales

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SIMULATING AVAILABILITY OUTLOOK FOR E-COMMERCE BUSINESS OF PERSONAL COMPUTER SALES

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ABSTRACT

For newly designed or transformed business processes, accurately predicting business performances such as costs and customer services before actual deployment is very important. We have successfully developed and used a simulation model for the IBM's Personal Computer Division by modeling multiple, discrete events such as customer order arrival, replenishment planning and availability data refresh, and uncertainty of demand forecast, order size and customer preference of product feature. Using the model we were able to predict dynamics of availability, ship dates and accuracy of ship date, and identified other opportunities for improvement. We have also studied how different inventory policies, supply planning policies and sourcing policies affect business performance metrics such as inventory and customer services.

1 INTRODUCTION

For e-commerce businesses, such as Web-based sales of computers, providing customers the desired lead time to shipment (a number of days for the product to be shipped after the order is placed) and actually shipping the product on time is a critical factor for success in today's competitive market. The lead time to shipment is determined and provided to customer in multiple times during the customers' e-shopping process. For businesses that are already in operation, when customers inquire the ship date, or place an order, the ship date is typically calculated by availability checking computer tool such as ATP (Available-to-Promise) system by checking master production schedule (MPS), inventory of the products and components, orders, forecasted product quantity, committed quantity, allocated inventory quantity, demand prioritization, and applying various ATP policies such as allocation policies, promising policies and other business rules etc. However, for businesses that haven't been in operations yet, such as when a new business is planned, a business transformation is planned or a business environment is expected to change, it is not easy to accurately estimate the profiles of the expected ship dates, such as a mean, range, standard deviation, skew and its change over time etc. Since the ship date is directly related to customer service, it is very important to accurately project the ship date profile before a new business process or its change is implemented.

Discrete-event simulation has been around for several decades to simulate stochastic behaviors of materials, services and information flow etc. in analyzing processes of manufacturing, services and various business operations. Especially, supply chain management (SCM) has been one of the areas where simulation method has been used to evaluate its effectiveness. Most of such usage has been to investigate inventory levels and customer service performance based on various manufacturing and distribution scenarios, and policies in inventory, manufacturing, replenishment and transportation. McClellan (1992) used simulation to study the effect of MPS method, variability of demand/supplier response on customer services, order cycle and inventory. Hieta (1998) analyzed the effect of alternative product structures, alternative inventory and production control methods on inventory and customer service performance. Bagchi et al. (1998) evaluated the design and operation of supply chain using simulation and optimization, analyzed SCM issues such as site location, replenishment policies, manufacturing policies, transportation policies, stocking levels, lead time and customer services. Yee (2002) analyzed the impact of automobile model and option mix on primary supply chain performance such as customer wait time, condition mismatch and part usage.

Business process modeling is another area where simulation methods have been actively used to identify business improvement opportunity by evaluating business process policies, process alternatives, and to estimate adequate resources for various tasks within a business process. Lee et al. (2003) simulated a business process of a computer manufacturer and identified a substantial process improvement opportunity in the business management cycle time by changes in processing steps and proper allocation of resources.

In this work, we describe a simulation model that estimates availability outlook, e.g., expected ship dates and their accuracy of an e-commerce business where end products are configured from different components by customers. This model simulates the effect of stochastic customer shopping traffic; uncertainty of order size, customer preferences of product features and demand forecast; inventory policies, sourcing policies and supply planning policies; manufacturing lead time etc. on the profiles of ship dates. The simulation model provides important statistical information of availability outlook and customer services before the business is put into operation so that intelligent business decisions are made before investment is made. The model also estimates the accuracy of the ship dates determination arising from frequency of data communications between the computer systems supporting the on-line business. For multiple quantity orders, the simulation model also computes ship dates for partial shipments, if it is optional, and the total shipment.

2 MODELING OF COMPONENT AVAILABILITY

Availability quantities of components that constitute the finished products are represented by multi-dimensional data array, with a dimension of number of components by number of time periods, shown as cylinders in the figure 1. The availability is time-dependent, e.g., there is availability for the current day (t=1), and there are availabilities for future days (t=2, 3, …) as the components are expected to be replenished in the future dates. For example, in the figure 1, the component 1 is available in quantity of 3 in the current day, and 5 more are expected to be available a day after, and 10 more are expected be available for 2 days later and so on.

The availability quantities of components are used in computing the ship date of customer requests and orders. The availability quantity changes as a result of four discrete events in the simulation. It changes as customer order is released, as replenishment is done, as data refresh is done, and as roll forward is carried. There are two instances of component availability arrays; one representing the availability at real time (dynamic view of availability), and another representing known availability according to the content of availability database (static view of availability) at the time of availability calculation. The latter availability is refreshed by a batch processing schedule as a result of the delay in the fulfillment process. For example, the availability data can be refreshed every few minutes or hours. The discrepancy between these dynamic view and static view of availability data is the cause of the accuracy of ship date calculation.

3 SHIP DATE CALCULATION

The figure 1 shows how the ship date calculation is simulated in this simulation model. Customer orders or requests arrive in certain stochastic interval as modeled with certain distribution functions. Each order has one or more line items, and each line item has one or more quantities. They are modeled with probability distribution functions. The line items and quantities are decided as the order is generated in the order generation event (details described in the next section). As the current order or request arrives in the simulation model, for each line item, certain components are selected as the building blocks of the product using distribution functions representing customer preference of component features. For example, in the Figure 1, the line item #3 of the order # 231, requires components 1, 3 and 4. At this point, different sourcing policies can also be applied in selecting specific components since components can be treated to exist in different pools, each of which is designated as specific availability for specific geographic sales region or customer class.

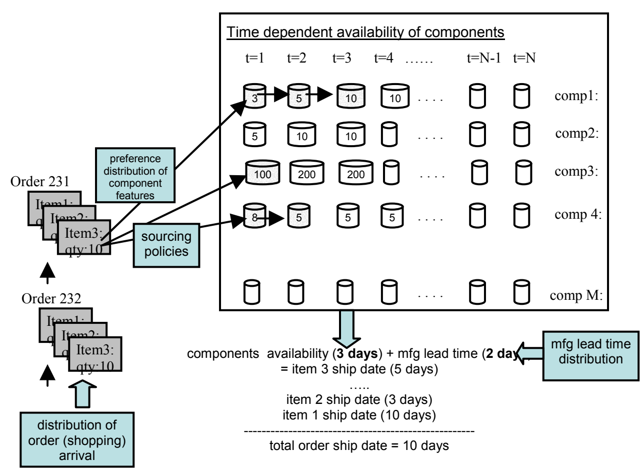

Figure 1: Simulation of Ship Date Calculation

For each chosen component, the simulation model looks for specified quantity starting from the current day to future dates until the availability of all quantity is identified. For example, for the component #1, the requested quantity of 10 is identified in the first 3 days; 3 in day1 (t=1), 5 in day2 (t=2), and 2 in day3 (t=3). Therefore, for the line item#3, the required quantity of component 1 is available by the third day. Similar search is carried out for component #3, which is available on the first day, and for component #4, which is available by the second day. Therefore, the component availability of line item#3 of the order#231 is the 3rd day. In this example, let's assume that the availability calculated for the line item# 1 is 8th day, and that of the line item#2 is 1st days.

When all the components are available, the product is assembled or manufactured and it takes certain amount of time, which can a fixed number of days or can be described with a distribution function. The lead time to ship date is then calculated by adding the manufacturing (assembly) time to the availability day. Assuming that the manufacturing lead time for this example is 2 days, the partial ship date for item#1 is 10th day, for item#2 is 3rd day, and for the item#3 is 5th day, if the customer is willing to receive the partial shipments. And the total order ship date is 10th day.

4 EVENT GENERATIONS

As explained in the previous section, the ship date of customer requests and orders are calculated using the availability quantities of components during the e-shopping experience as requested or at the time of order placement. In this method, the availability quantity changes as the result of four events; (1) order generation event, (2) replenishment event (3) roll-forward event, and (4) data refresh event. The events are generated independently using probability distribution functions or fixed intervals. The model can be easily extended to include more events.

4.1 Order Generation Event

Customer orders are generated in the invention in certain stochastic interval as they are modeled with certain distribution functions. At this time of the order generation, each order is assigned with one or more line items, and each line item is assigned with one or more quantities. This assignment of attributes to each order is modeled with probability distribution functions based on historic sales data or expected business in the future. The orders travel through the business process as defined in the simulation model, and when the orders reached a task which simulates the customer submission of the order, specified availability quantities of components are reserved for the order, and are decremented from the availability. The allocation of specific components are decided by the sourcing policy, distribution of component feature preference, customer class etc.

4.2 Replenishment Event

As building block components are consumed as products are sold to customers, additional components are acquired through planning of supply. This activity, typically known as supply planning, occurs in advance, e.g., months, weeks or days before the components are actually needed, to accommodate the supply lead time. The frequency of supply planning can also be months, weeks or days. As a result of the supply planning, the component availability is replenished in certain frequency and quantity. The replenishment frequency can be a fixed interval such as daily, weekly etc, or it can be modeled using a distribution function. The replenishment quantity is based on the forecast of customer demand, which has uncertainty. The replenishment quantity is modeled using a distribution function, typically a normal distribution with certain mean and standard deviation, which represent the uncertainty of demand forecast. In this work, we use the historic demand distribution data to arrive at the distribution function. Here, various replenishment policies can be modeled to specify the frequency and size of the replenishment.

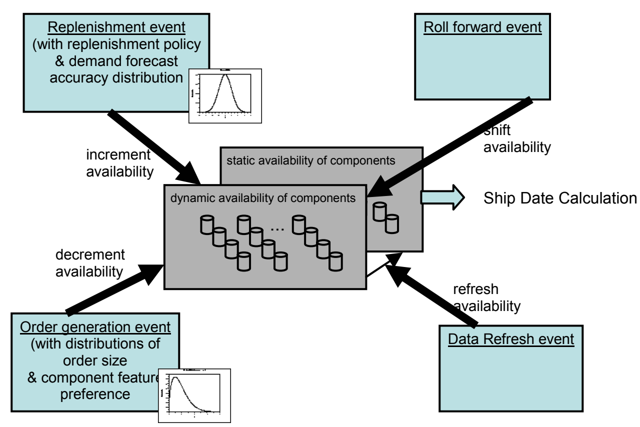

Figure 2: Multiple Events That Affect The Availability of Components

4.3 Roll Forward Event

As simulation clock moves from a day to another day, the component that has not been consumed are carried forward to a day earlier. For example, the availability quantity for the 2nd day will be the availability quantity of 1st day, and that of 3rd day will be that of 2nd day etc. Also, the availability quantity not consumed on the 1st day stayed on the same day, assuming it is non-perishable. The roll forward event can be generated in a fixed interval, e.g., daily, or different roll forward events can also be modeled based on the business environment.

4.4 Data Refresh Event

In ideal e-business environment, when a customer order for a specific product is accepted, the components that constitute the product should immediately be reserved and not available for future orders. However, in reality the availability data are not updated in real time. One of the reasons is that several computer systems are involved in processing and fulfilling customer orders, and their data are not updated and synchronized in real time because it is expensive to have IT architecture that ensures such data communication and synchronization. Another reason is that the order fulfillment tasks, which may include scheduling, production, distribution and accounting etc., takes some time or are typically carried out as a batch process. The batch process is executed in certain time intervals, and the availability data is updated only after the fulfillment tasks are completed.

The discrepancy between the real availability (dynamic availability) and the known availability (static availability) causes the accurate ship date calculation. In this work, the ship date is computed using both dynamic and static view of the availability, as shown in the Figure 2, and the inaccuracy of the ship date calculation is estimated. The inaccuracy of ship date calculation is an important indication of customer service level. The data refresh event can be modeled as fixed interval event or randomly generated event described by distribution functions.

5 SAMPLE SIMULATION RESULTS: SHIP DATE PROFILE AND ITS ACCURACY

Figure 3 shows a sample profile of ship dates over time as a result of a simulation run. Here, the ship dates fluctuate between 3 days and 10 days with a mean ship date of 4.4 days and the standard deviation of 1.76 days. Figure 4 shows the inaccuracy of ship date calculation based on the availability data refresh frequency of 8 hours. In this example, the ship date is inaccurate as much as 4 days, and 8% of customer requests or orders will have incorrect ship date.

6 SUMMARY

Customer service is one of most important factors of success and survival of enterprises in today's dynamic business environment. Being able to estimate availability outlook and expected customer services before investment is made to run the business is quite beneficial to any enterprises. We have developed a simulation model that estimates the ship dates, one of most important customer service factors in on-line sales business, and how accurate the promised ship date is. By simulating various business scenarios, analyzing expected ship date statistics and comparing the costs of running the scenarios, we were able to make intelligent business decisions to promote higher profits and better customer services. The simulation modeling work was done using the IBM WBI Modeler (IBM Corporation).

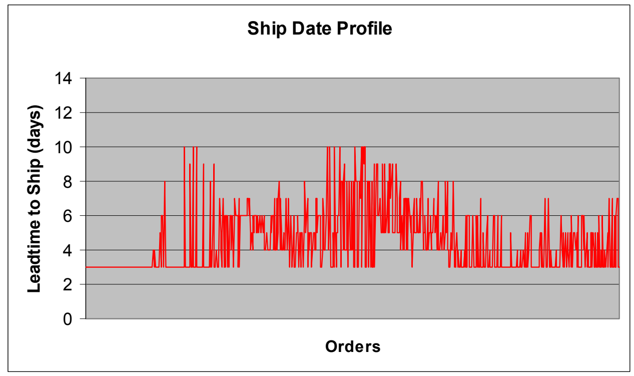

Figure 3: Example Ship Date Profile

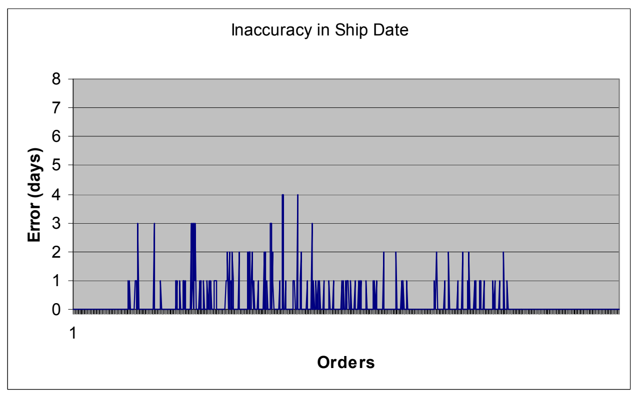

Figure 4: Example of Ship Date Error

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