Customer Order Scheduling System for SABRE Travel Information Network (STIN)

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Abstract

SABRE Travel Information Network (STIN), a provider of one of the world's largest computer reservation systems, is trying to improve customer service levels during order processing. To address STIN's need to improve customer service, SABRE Decision Technologies (SDT) has designed and is developing a scheduling engine for STIN's new order scheduling decision support system called the Customer Order Scheduling System (COSS). The primary objective of COSS is to schedule orders to meet the customers' want dates (a want date is a requested completion time of a milestone in an order). The scheduling engine allocates equipment and human resources as it schedules milestones associated with customer orders. The engine intelligently generates schedules for all customer orders given the pool of shared resources while respecting customer specified completion dates (or want dates), user-defined scheduling rules, and customer priorities. Schedules are built based on customer priority, type of order, want date, as well as labor skill and equipment availability. For operations worldwide, STIN plans to rely on COSS for planning and scheduling support.

This paper describes the current design and implementation of the COSS scheduling engine. The scheduling engine is being developed in C++ in a UNIX environment using ILOG Solver and Schedule constraint libraries. The customer priority rankings and order type rankings were implemented in the selection criteria used to decide in what order the tasks should be scheduled.

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1. INTRODUCTION

SABRE Travel Information Network (STIN) , a wholly owned subsidiary of AMR Corporation (parent company of American Airlines), in an effort to improve customer service, needs to automate the planning and scheduling of major order processing milestones. STIN is primarily responsible for marketing SABRE (Semi-Automated Business Research Environment), one of the largest privately owned, real-time computer reservation systems in the world, which provides travel distribution and information services to nearly 30,000 travel agencies worldwide [AMR 96]. In recent years, competition has increased among major reservation system providers and STIN has recognized a need to improve its customer service to maintain its market share. STIN has identified a major business change that is needed for improving customer service: incorporate customer preferred completion dates (also called want dates) into the planning stage of order processing. Currently, customer orders are processed with the assumption that they should be completed as soon as possible when in actuality, this may not be what the customer wants or needs.

Customer orders usually include requests such as install a new customer (an *add* order type for a new customer), install additional equipment at a current customer site (*add* order type for an existing customer), move a customer to a new site (*move*), rearrange a customer's hardware setup at a current site (*relocate*) or disconnect equipment from a current customer site (*delete*). The major activities (also called milestones) associated with a specific customer order might include: surveying the customer site, ordering permanent datalines, preparing equipment for shipping, installing equipment, and disconnecting equipment. Some of these milestones require STIN resources and others just impose precedence constraints on related milestones.

Currently, no overall plan or schedule exists for STIN customer orders. Dispatchers serve as human schedulers, deciding when equipment will be shipped and which technician will be assigned the service task of installing or disconnecting equipment. Orders begin processing as soon as possible, but the schedulers do not have the benefit of knowing all the other orders that are being placed. Many orders turn into rush jobs, placing undue strain on STIN resources that could have been prevented with adequate planning. To automate this scheduling process and incorporate STIN's new objective of meeting customer want dates, COSS, a constraint-based scheduling system, is being developed. ILOG Solver and Schedule C++ libraries are being used as the primary tools for modeling and developing the scheduling engine of COSS. COSS is expected to be a decision support tool that frees up the dispatcher from doing forward scheduling and schedules customer orders based on the customer want dates and resource availability.

2. SYSTEM GOALS

The most important concern for STIN is the ability to consistently meet customer specified want dates. The ability to promise and meet a want date has an important impact on the overall perceptions customers have of STIN. In the case that a want date cannot be met, the system should provide the closest possible feasible completion date and should specify which milestone, if any, is the bottleneck for delaying the customer want date. Planning in advance and giving the customer that information can help the order process run more smoothly.

Another goal for the system is to reduce the amount of manual effort required for scheduling. By automating the planning and scheduling of standard customer orders, STIN dispatchers will be free to focus their full attention on exception handling and "hot" orders.

Rescheduling is another important design requirement. In addition to the scheduling engine, COSS will have a monitoring module for order tracking. This module will provide alerts when a milestone is not completed on the planned date. It will show the impact of a late milestone on the remaining milestones of a customer order and allow the user to reschedule those remaining milestones. System users will be able to perform *what if* analysis on hypothetical dates, using COSS's scheduling engine to reschedule orders and generate feasible schedules that complete as close as possible to the original want date.

3. SYSTEM ARCHITECTURE

COSS is the planning and scheduling component of STIN's new order processing system, namely Customer Service Delivery Process (CSDP). The order entry system of CSDP, SaleMaker, resides locally on each field sales representative's laptop computer. The orders are entered via the SaleMaker tool, and stored in a Personal Oracle database. These Personal Oracle database tables are replicated on the central UNIX server. The central server also houses COSS and the information management system, JBA. Figure 1 is a diagram of the information flow in the CSDP system, from the COSS point of view, and with COSS as the focal point.

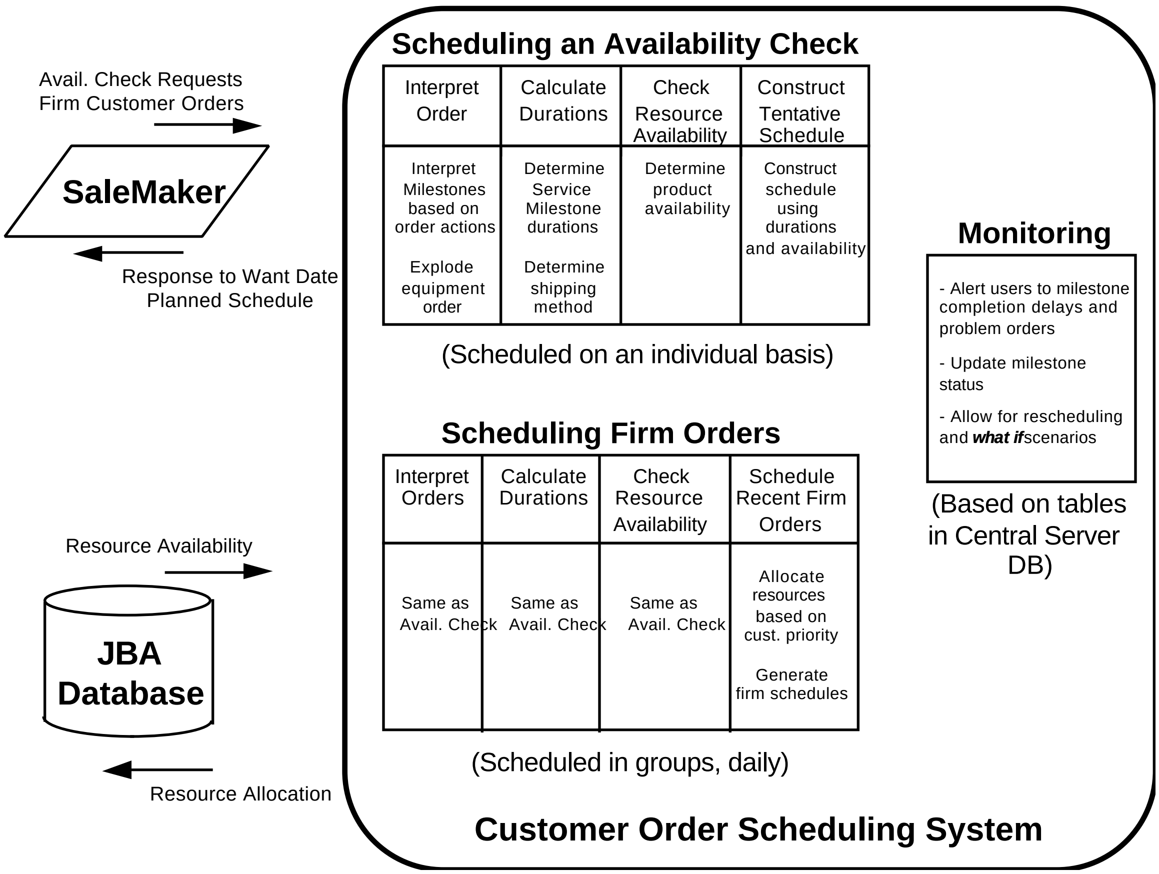

Figure 1. The overall system architecture of COSS.

The field sales representative enters a new, tentative customer order using SaleMaker. This customer order specifies what milestones comprise the customer project. The field sales representative then sends the order to COSS for preliminary scheduling (also known as availability checking). COSS generates a schedule taking into account the current customer orders, this tentative customer order, the current inventory, outstanding purchase orders, and the lead time required for ordering new equipment. The result is a possible schedule. This information is sent back to the SaleMaker, as shown in Figure 2. Should the user decide to order, the order is again sent to COSS for scheduling. This time, however, the order is considered among all currently unscheduled customer orders. It is scheduled in a batch run (typically one run per night) that attempts to optimize the use of the resources without greatly perturbing the current customer commitments.

```
The availability check indicates that Customer Order BR-549 could be completed on
03/26/96 which is on time for the requested completion date (03/26/96).
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```
Remember that this date is based on current  information  and  is  subject  to  change
without notice.

STINCustomerOrder for STINCustomer Fred Garrett (MomAndPop)
 LAX 03/26/96 state = Availability Check
 substate = ADD
 with 5 Milestones  and 18 Records
 in schedule STINProjectI(02/12/96 to 02/11/97)

STIN Milestone MS-SSURVEY
 No want date specified.
 Start Date: 03/16/96
 End Date  : 03/17/96
BR-549MS-SSURVEY[33 -- 1 --> 34]

STIN Milestone MS-TELCO
 No want date specified.
 Start Date: 02/28/96
 End Date  : 03/24/96
BR-549MS-TELCO[16 -- 25 --> 41]

STIN Milestone MS-SABRE
 No want date specified.
 Start Date: 03/14/96
 End Date  : 03/24/96
BR-549MS-SABRE[31 -- 10 --> 41]

STIN Milestone MS-EQUIPSHIP
 Want Date : 03/20/96
 Start Date: 03/17/96
 End Date  : 03/19/96
BR-549MS-EQUIPSHIP[34 -- 2 --> 36]

STIN Milestone MS-EQUIPINST
 Want Date : 03/26/96
 Start Date: 03/24/96
 End Date  : 03/26/96
 (This is the Key Milestone)  BR-549MS-EQUIPINST[41 -- 2 --> 43]
```

Figure 2. Information sent to Salemaker from COSS.

4. CONSTRAINTS

When a customer order is received for an availability check (preliminary scheduling), COSS first determines the resource requirements and the dependencies among the milestones of the customer order.

Feasible schedules must satisfy the following categories of constraints:

- o Temporal constraints - there are numerous precedence relationships among milestones, e.g., equipment installation can only begin after the shipment has arrived at the customer site.

- o Resource constraints - certain milestones require equipment or a person before they can be performed, e.g., equipment installation requires one technician (a STIN employee or a trained outside vendor).

All of the temporal constraints needed to formulate STIN's scheduling problem are represented using the *IlcActivity* class member function *startsAfterEnd*. This function states that the invoking activity can start only after a specified activity ends [ILOG 95]. For example,

IlcTell (phaseInTraining.startsAfterEnd(equipmentServiceInstall),

represents the constraint that the installation of equipment at the customer site must complete before training may begin.

STIN equipment resources, i.e., software and hardware, and human resources, i.e., technicians and trainers, have been defined as discrete resources. Equipment is *consumed* (using ILOG terminology) by associated milestones since the equipment remains at the customer site and is not returned to inventory upon completion of the milestone. Technicians and trainers are *required* by a milestone and subsequently returned to the resource pool when that particular milestone is completed.

The initial available quantity of an equipment resource is the quantity in inventory now. This quantity is incremented by outstanding purchase orders, starting at the date the orders are expected to be received. The quantity is also incremented by the amount of the largest order that could be processed, taking into account the lead time for ordering this equipment. This prevents scheduling failures due to a lack of resources that may be procured. A post-processing step determines how much of a resource, if any, needs to be ordered based on the current (firm) schedule.

The initial available quantity of a human resource is determined by the calendar of the resource pool in a given location. Typically, human resources are associated with the airport nearest them. Note that the resource requirements for human resources are disjunctive (for example, equipment installation milestones require either a STIN employee or a trained outside vendor). There are preferences to use STIN employees if available. Otherwise, an outside vendor is used. The pool of outside vendors is currently considered unbounded (that is, for all practical purposes, infinite). This prevents scheduling failures due to a lack of internal resources for milestones that may be subcontracted.

5. SELECTION CRITERIA

STIN's current business practices indicate that customers are prioritized based on the revenue they generate for STIN and order types are ranked based on whether a customer is already a SABRE user. Based on these fundamental prioritizations, the following dispatching rule / selection criteria is best fit for achieving STIN's primary objective of meeting customer want dates.

When creating a schedule for all of today's firm orders, COSS will use the following selection criteria to determine which milestone to schedule next. The first two criteria are at the order level and the remaining three criteria are at a milestone level.

1. Select all unscheduled milestones associated with orders of the highest priority customer(s).

2. From the set of milestones generated by step 1, select all milestones with the highest priority order type.

3. From the set of milestones that remain after step 2, select all *key* milestones.

4. If all the key milestones have already been scheduled, select all the milestones that have want dates associated with them.

5. If after considering steps 1-4 there is still more than one milestone from which to choose for scheduling next, select the milestone whose latest possible start date is the minimum (or earliest).

The concept of Schedule's *IlcActivitySelector2* is used to build the milestone selector [ILOG 95]. However, the predefined macro has not been used because there are five criteria that need to be considered in the selection process.

Once a milestone is selected, an attempt is made to instantiate its constrained *end time* variable with the value of the customer want date. This propagates throughout the rest of the constrained variables, i.e., start and end times for other milestones. If this assignment is infeasible, then the customer want date is removed from the domain of the milestone's *end time* variable and the next closest date is attempted. If no want date is specified for a milestone, then the milestone is instantiated with the date closest to the order's key want date which is still feasible with respect to precedence constraints and resource requirements. This compresses the schedule so that milestones that must complete prior to the key milestone are scheduled as late as possible, and similarly milestones that start after the key milestone are scheduled as early as possible. *InstantiateWithClosest* is a goal that incorporates the logic of setting a milestone's end time to the want date, or as close to that date as possible. Note that a milestone is not constrained to end by the want date. This allows the want date to be treated as a soft constraint (i.e., a constraint that can be violated) should some resources be oversubscribed.

6. IMPLEMENTATION STATUS

COSS is currently under development in a UNIX environment on an IBM RS/6000. It is being developed on the same server that will be used in production mode. All of the orders, resource availability, and lead-times will be stored in an Oracle relational database, however, many of the tables are not yet populated. Thus, testing is currently being done with flat files. SaleMaker is not currently available, so the current implementation reads a file that represents the order and sends e-mail to the user with feedback from the availability check (Figure 2). For the sake of consistency, STIN has specified the GUI development package that is being used; the same package was used to build the front end of STIN's order information system. (The interface for the COSS prototype was developed in ILOG Views. It uses Views' Gantt chart to display the resulting schedule to the user.)

STIN plans on putting COSS into production mode in the first quarter of 1997 for their European operations. Use in North America, Latin America, Asia and Africa is anticipated to begin in mid 1997.

7. CONCLUSION

The Customer Order Scheduling System (COSS) is the decision support scheduling system for STIN. The authors have designed and are implementing the scheduling engine for COSS. COSS is considered critical functionality required for STIN's new Customer Service Delivery Process. It is the primary vehicle for planning orders to meet customer want dates and reducing routine manual intervention in customer orders. Beginning in 1997, STIN will be working to achieve a higher standard of customer service and COSS will help them maintain that standard.

8. REFERENCES

[AMR 96] *AMR Corporation 1995 Annual Report*, 1996.

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[Le Pape 94] C. Le Pape, "Using a Constraint-Based Scheduling Library to Solve a Specific Scheduling Problem". In *Proceedings of the AAAI-SIGMAN Workshop on Artificial Intelligence Approaches to Modeling and Scheduling Manufacturing Processes*, TAI, New Orleans, Louisiana, 1994.