Proceedings of the 1994 Winter Simulation Conference
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TUTORIAL ON SIMULATION APPLICATIONS

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ABSTRACT

This paper discusses two simulation applications. The first one is a resource planning simulation done for the Hennepin County Dept. of Community Corrections. The goal of this simulation was to study the impact of a new contact standard for offenders on supervisor workload and other factors. The second application was developed at Northwest Airlines to determine if additional automated test equipment would benefit the operational performance of its Avionics shop.

1 HENNEPIN COUNTY SIMULATION

1.1 Introduction

In 1991, Hennepin County represented 24% of Minnesota's population, but 52% of the state's reported violent crimes and 34% of the state's reported property crimes. The County's probation officers and parole agents, fixed at a total of 66, supervise about 4,000 to 5,000 adult offenders, and this number has approximately doubled since 1988. The Department of Community Corrections was forced to reevaluate standards regarding frequency and length of contact based on the seriousness of the crime and new convictions of an offender. Currently, the contact standards are determined by the supervisors.

Offenders arriving to Community Corrections are either probationers from the courts or the county workhouse or parolees from prison. An offender is assigned an officer upon arrival based on certain assignment constraints; e.g., female parolees can be assigned to certain supervisors, etc. According to the new contact standard, an offender has a face-to-face contact based on a particular schedule. Each supervisor has six appointment slots per day. Given that restriction, it is possible that an offender can not make an appointment with the assigned officer according to his/her schedule. This is clearly an undesirable problem.

The management was interested in the effect of the new contact standard on various factors; among these were the need to hire additional supervisors, limits on the number of appointments a supervisor could handle, the effects of an offender picking up new convictions and reentering the system, etc. To achieve this without actually implementing the new standard and possibly disrupting the system, we decided to use simulation methodology. The goal of this simulation was to observe the system under the new standard, balance officers' workloads within given constraints and measure the performance of the system by officer's workload and number of failed attempts at making an appointment with the assigned supervisor.

1.2 Simulation Model

The basic structure of the simulation model is discussed in this section. The initial condition for the simulation was the current state of the system. Based on collected data, we used probability distributions to represent the number of offenders currently in the system.

The model consisted of three events described below.

1. Arrival: There were two types of arrivals. Offenders arrived either from the outside (court or prison or workhouse) or as a result of a new conviction while going through the system. Here a new offender was assigned the supervisor having the Least Work Remaining in the class of assignable supervisors.

2. End-appointment: In this event, an offender made the next appointment with the assigned supervisor if this was not his/her last visit.

3. End-simulation: The simulation was run for six years.

The performance measures we considered were as follows:

- The time-average, maximum, and minimum caseload per supervisor.
- Proportion of failed initial and non-initial attempts to make an appointment.

The 6-year long simulation was computationally expensive. It required 40 minutes on CRAY-2 and CRAY X-MP computers. We replicated the run three times resulting in reasonably small standard errors of estimates.

As a part of our analysis, we considered three scenarios in response to public-policy considerations.

Scenario 6: This is the base case where the number of appointments a supervisor would be able to have is six.

Scenario 5: Here the number of appointments is reduced to 5 to make a supervisor's load realistic in consideration of his/her other responsibilities.

Scenario 5s: This is the same as scenario 5 except that all sex offenders are required to have significantly increased contact than in the previous two scenarios.

We used common random numbers for all scenarios.

2 ATEC-5000 SIMULATION

2.1 Introduction

Repair shops are at the heart of the maintenance operation of an airline. Safe and efficient operation of these shops is crucial to the airline's success. The shops repair components removed from an aircraft and make them reusable. The time a shop takes to repair a part directly affects the spares we must have to keep the aircraft flying. Many aircraft parts are expensive. So the goal is to have an efficient repair process so that we reduce the number of spares needed.

A component is removed from an aircraft if it is not functional or if it has been on an aircraft for a pre-determined length of time. A part thus removed enters a repair shop, where it is first tested to locate a fault. It is possible that a part may be in good condition, not needing repair. Such parts are labeled *no trouble found* and are put back in service. If the test identifies a problem with a part, it is either scheduled for repair in the shop or sent to an outside vendor for repair. Upon completion of its repair, it is once again tested to make sure it can be put back in service.

Avionics is one such shop where removed parts are placed in a priority queue for the automated test equipment, ATEC-5000, and then they follow the process described above. The shop, at the time of this simulation, had one ATEC-5000. The shop's workload dictated a need for a second ATEC-5000. Before committing to such an investment, it was necessary to predict the improvement in operational performance of the shop due to an additional ATEC-5000. Simulation was the tool used to accomplish this.

2.2 Simulation Model

This section describes various pieces of the simulation model. The goal of the simulation was to estimate the impact of an additional ATEC-5000 on queue length and shop cycle times; shorter cycle times would result in increased shop capacity. We will start with the stochastic elements.

The arrival process of removed parts to the shop was described using a probabilistic distribution. The two ATEC-5000s were available at all times except when they were down for maintenance. The calibration periods of the two machines were synchronized to avoid an overlap. Unscheduled maintenance was accounted for by a probability distribution. As for manpower availability, we considered in the model mechanics' scheduled time-off such as lunch, coffee and clean-up breaks, vacations, and unscheduled time-off such as sick leaves. Mechanics' overtime needed to meet the repair requirement was also a factor of interest. The model generated overtime requirements based on the queue length at the ATEC-5000s. The ATEC-5000 processing time, which included setup time, initial testing time, repair time and final testing time, was based on an expert opinion as well as the data collected from the first ATEC-5000.

Queue discipline for the base model took into account the service level contribution of a part inversely weighted by the labor hours required to repair the part. So one repaired a part that provided higher service level with less labor.

The base case scenario is described above. The system was simulated for two more scenarios—increased arrival rate of parts and no overtime—to test the stress on the system.

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ACKNOWLEDGMENTS

Computational support for the Hennepin County project was provided by the Minnesota Supercomputer Institute. Portions of this article appeared in the *Proceedings of the 1993 Winter Simulation Conference* and in the Technical Report published at Northwest Airlines.

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