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THE USE OF SPECIALIZED MODELING AND DISPLAY TECHNIQUES IN THE SIMULATION ANALYSIS OF A NEWSPAPER MAILROOM DISTRIBUTION SYSTEM

Barbara M. Werner
Systems Modeling Corporation
504 Beaver Street
Sewickley, PA 15143

ABSTRACT

The production of the familiar local newspaper can become a complicated and challenging scheduling and distribution problem. Expanded circulation, zoned advertising and customized local news have forced newspapers to produce many variations of the traditional single product daily newspaper. Currently, a "main jacket" (a basic regional newspaper without specialized advertising) is only a building block for more complex products. Any time additional sections are "inserted" into the main, the paper becomes classified under a new product code. Operations are now dealing with simultaneous processing of dozens of products in a high-speed, demand-driven environment.

Simulation and animation are being used to aid in the operational design and testing of new, flexible newspaper production and distribution facilities. This paper discusses the analysis of the scheduling problems of a specific newspaper while highlighting the benefits of using specialized modeling and display techniques during analysis. The paper contains the following sections: adding dual screen run-time output, creating reusable models by structuring for generic system qualities, and developing model specific user menu systems.

1. MANUFACTURING ENVIRONMENT

The packaging and distribution area of a newspaper facility, called the mailroom, was traditionally designed with many single exit, parallel processing lines. Each printing press was attached to a dedicated "tying" line where papers were stacked into bundles, wrapped with a protective bottom cover paper and tied. Each line ended at a dedicated truck dock location for pick-up and distribution. When all lines were producing the same product, trucks could arrive at any dock, get their papers and leave promptly. Once zoned advertising and specific local news sections were added, different presses began running different products and therefore docks became dedicated to certain products. When trucks carried orders for multiple products, they were forced to sequentially wait in line for each dock that supplied a required product. As the number of products in a mailroom expanded, and subsequently the number of possible order combinations increased, truck loading times increased and the congestion and confusion at the docks escalated to unmanageable levels.

Unlike many manufacturing facilities, a newspaper is a terminating system with daily time deadlines for production and distribution. Every day the system starts out empty and must finish empty. Because of varying amounts of news, each run can also be different from the previous day's. In addition to the overall requirements, success is also measured on the ability of individual trucks to arrive at their destinations on time. Therefore global, average efficiency is not the only concern. Each individual trucks must also have a short turnaround time. The policy of using dedicated docks and multiple products was destroying the individual truck efficiencies.

2. NEW TECHNOLOGY

Hall Processing Systems, a material handling vendor dedicated to the newspaper industry, set out to provide a flexible sorting and distribution system that would reduce congestion and expedite the loading process for individual trucks. The developed system (called a "Tray" system) is a high-speed, carousel bucket conveyor that accepts products (bundles of papers) from a set of tying lines and distributes them to a bank of loading docks. This allows any truck, at any dock, to load a product being produced on any press or inserter. Trucks can also stay at a single dock location and receive all products in their orders.

Hall felt that the newly created manufacturing environment of multiple high-speed production lines (producing up to 70,000 papers/hr each) feeding into a single distribution conveyor needed to be tested for capacity. A SIMAN simulation model was created to test the capacity of the conveyor under worst case conditions: simultaneous multiple product input, with controlled distribution to trucks at flexible dock locations, each with multiple product orders. As analysis of the system progressed, it became apparent that the critical issue was not capacity but rather scheduling.

The Tray conveyor is the only buffer area for all products in the distribution system. A press is rarely stopped once a product run has started. Barring an emergency, product changeovers are the only stop condition. This essentially causes a continuous flow of product into the Tray. As long as there is a truck at the dock demanding the product that is running, the bundles will simply flow from entry point to dock with little effect on the rest of the system. However, if no demand exists, the bundles will continue to feed into the Tray and will quickly clog the conveyor so other products cannot find empty buckets. The challenge then became one of balancing the production schedule with the truck loading schedule to develop a workable operating scenario. (See Figure 1. System Layout)

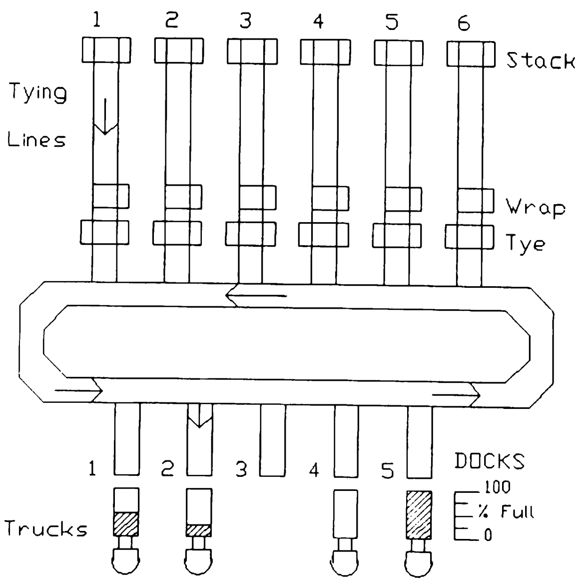

Figure 1: System Layout

3. ANALYSIS TOOLS

Once the Simulation model was created, the attempt to test the existing truck schedules was hampered because the system would continually fill the Tray due to unbalanced supply and demand. Assuming that the production schedule was stable, it was necessary to amend the loading schedule to match production. Animation and dynamic textual output were critical in identifying the sensitive points in the truck schedule.

3.1 Role of Animation

A CINEMA animation became a vital part of the project, both as an analysis tool and as a communications vehicle. The client, Hall Processing, was new to simulation and did not have time to learn the details of simulation code or the modeling process. By watching an animation of the Mailroom system, the non-simulationists were able to understand what was happening as demand and supply became unbalanced, and were subsequently able to participate in experiments to improve the situation.

As the system became congested on the animation, the current position in the schedule was noted and trucks were moved around to smooth out the demand flow. Sequencing restriction and general heuristics, provided by the client, were implemented to reduce the congestion. Once the major problems were identified through the animation, statistical analysis continued. We ran multiple replications of the system to gather output that could predict average and extreme system performance and individual truck performance.

Use of the animation dramatically reduced analysis time and provided a visual aid for direct experimentation. Identifying where and why the schedule started to break down, would have been quite difficult without the graphical output. Summary statistics could never provide the necessary insight into the dynamic interactions of the system.

In addition to analysis functions, the animation also played an important role in the presentation of results to decision makers. It was necessary to provide complete, concise examples of the critical situations that required operational changes in the system. The snapshot functionality of CSIMAN, made it possible to save and recall animated examples of smooth-flowing and congested system conditions.

3.2 Special Display Features

Historically, animations were designed to provide a graphical display of the dynamic flow of parts through a system. The picture condenses a large volume of numeric variables into a single source of comprehendible information. Animations can clarify control logic, component interactions, and global system conditions. If other pieces of information or means of control would be helpful as dynamic output, other forms of display should be considered to enhance the functionality of an animation.

3.2.1 Dual Monitor Display. In order to display comprehensive information, a dual monitor system was utilized during animation run time of the mailroom model. While the animation was running on the graphics monitor, a two window, formatted display was maintained on the text monitor. A large window provided detailed truck and order information that would be difficult to display through symbols on the animation. When the graphical symbol for a truck arrived at a dock, the corresponding order information, including the complete list of required products and quantities, would be written to the text window. A star character ("*") was used on the text screen to indicate which product in each truck order was currently being loaded. As the truck switched to loading its second and third products, the star would move to the appropriate column on the order information. Graphically, a CINEMA "level" (a dynamic bar graph attached to a specific variable) was used to represent the percent of the current product quantity that had been loaded. In Figure 1., note that the truck at dock location 1 is 50% finished loading its first product (see star indicator in Figure 2. Text Display: Dock Status Window), the truck in dock location 2 is 25% finished loading its second product, and the truck in location 4 is just starting to load its first product. Using the graphical levels and the star indicator on the text screen, it was easy to estimate when a truck would finish loading (the truck at dock 5 is just finishing its last product), and therefore free up a dock for new orders.

Dock	Route	P1	Qty	P2	Qty	P3	Qty
1	E522	04	*120	12	75		
2	F33	02	45	04	* 300		
3							
4	D13	12	* 95	02	85		
5	A23	04	240	02	30	01	* 45

TIME: 54.96

Truck # 20 Route E82 Arrived at dock 3
at Time 44.90 Avg. Bundles/min = 8.236
P1 = 6 Qty = 43

Figure 2: Text Screen: Dock Status Window/Message Window

This order information was particularly helpful in detailing the situations that caused the Tray to fill up. For example, by scanning the text screen order information, it was easy to see that there were too many large orders for the same product type at a given point in the schedule. This situation would decrease the turnaround rate and restrict the number of trucks that could be loading other products. Observations at other times showed too many small orders grouped together, causing blocks of time with many empty docks due to fast turnaround. This situation also caused the system to deteriorate because there were too few destinations for the volume of production.

The bottom portion of the text monitor was used as a message box window. This window displayed truck information each time a truck arrived or departed from the system, essentially calling attention to changes in the system status. In the example in Figure 2., the message window shows summary performance information for the truck that just left dock 3.

3.2.2 Run-Time System Modification Menu. In the process of defining system control logic, it was useful and expeditious to provide a mechanism for forcing "random" events to occur. In this way we could quickly test the modeling of the logic without waiting for statistics to create the scenario in question. To allow the non-simulationist to perform dynamic experiments on the system, a run time window-type menu system was implemented on the text screen. At any time during the run, the menu could be called up by pressing a designated key. Through options on the menus, the user could make system changes such as causing a machine failure or altering a loading rate or truck turnaround distribution. (See figure 3. Run-time Modification Menu) The menu interface eliminated the need to know the details of the model design or the model parameters that controlled the system states or conditions in question.

Newspaper Mailroom
Simulation Model
Run-Time
Modification Main Menu

1. Truck Dock Information
2. Press Status On/Off
3. Inserter Status On/Off
4. Stacker Status On/Off
5. Tyer Status On/Off

ENTER CHOICE :_

Figure 3: Text Screen: Run-time Modification Menu

Once debugging and analysis were complete, the menu system also provided flexibility for presentations. A demonstrator was able to quickly create critical situations on the fly as questions were posed by an audience. For expert and non-expert, the menu system proved to be a useful analysis and demonstration aid.

3.3 Pre-scheduler Utility

In designing a new mailroom facility, it was necessary to develop new truck schedules that would work with the new operating environment. After feeding in numerous hand developed schedules that repeatedly clogged the system, a program was developed to pre-balance supply and demand. The short utility program read in a prioritized list of truck orders and planned production schedules, and created a rough-draft schedule to read into the simulation model. The utility estimates the gross production of each product for every 15 minute period, then adds trucks with appropriate orders to the schedule, until the supply is satisfied. The resulting schedule was used as input to the simulation where variability factors of breakdowns, random truck turnaround delays and variable hand processing cycles were applied. By performing a set of simulation runs on the created schedule, average expected performance could be determined for the system and for each individual truck.

4. MODEL FLEXIBILITY FOR GENERIC APPLICATION

When creating simulation models, it is important to consider the skills and needs of the end user. Questions such as the following can help to define how the model should be structured and designed:

1. Is the model going to be used for a one time analysis or could it be reused in the future?
2. Is the system being modeled a unique set up or is it a minor variation of a typical system?
3. Is the user an expert in simulation, or an expert in the operation of the real system?

Answers to the first two questions help determine how much effort should be spent developing a generic model. If the system in question can fit into a standard system description and there is reason to believe that other similar systems will need analysis in the future, it is beneficial to generalize the model and use macros and variables.

In the newspaper business, processing is similar from city to city. The differences include total output volume, specific truck loading schedules, the type of distribution system and the physical arrangement of equipment. Hall Processing designs and builds Tray distribution systems for North American newspapers. Each system they design is a variation on the theme of multiple tying lines feeding a carousel conveyor, and distributing to a bank of loading docks. As Hall initiated the use of simulation, to help a specific city newspaper design a new facility, they decided it would be most useful to have a model that was flexible enough to test other mailroom systems. Hence the call for a generic mailroom model.

4.1 Macros and Variables

Since printing and tying are still done on multiple, identical lines, this part of the model was constructed using SIMAN station macros. Station macros allow a model to be used to depict systems with a variable number of parallel processing lines. To modify the number of lines in use, the model starts off with all lines down and checks a variable to determine how many to turn on. In a similar fashion, there is a variable for the number of active truck docks. As trucks arrive to the system, the model will only utilize the number of docks specified. These built-in switches will allow the definition of a system with any number of input lines feeding into any number of docks (up to the maximum).

System operating rates such as machine cycle times, conveyor speeds and truck loading rates are all modeled as variables accessible through the experiment frame. These variables, combined with the flexible model structure of macros, allow the user to easily reconfigure the system, without the need to alter the model frame.

4.2 Flexible FORTRAN Subroutines

The logic of the tray distribution system consisted of determining where to send each bundle of papers as it entered the conveyor. A generic FORTRAN event was created that would simply try to match the new bundle to the pending orders currently at the docks. The event would search from dock 1 to the current number of active docks, assign the bundle a destination dock or send it all the way around the loop if there were no matching orders. FORTRAN statistics were also kept to allow the event to prioritize among trucks requesting the same product. The event had no knowledge of the number of products being run or the specific number of tying lines or docks; it simply performed the control function with whatever input it was given and the current value of the system variables. The generic nature of the event allowed the system configuration to change through the experiment frame without requiring changes to the FORTRAN code.

4.3 Model Specific User Menus

Answers to the third question, concerning the characteristics of the model user, can suggest what type of interaction should be required to alter the model. For someone who is familiar with simulation, and the language the model is written in, it is usually sufficient to provide well documented listings and a users guide. A users guide can describe the general data structures used and can map out what variables can and cannot be changed in the experiment frame. Good model design should allow a second party user to make all necessary changes in the variables in the experiment frame and require none in the model itself.

If the user is less knowledgeable about simulation, it is important to provide an effective interface tool. The tool must provide a simple mechanism to exercise the model without requiring knowledge of the details of file structure. One possible interface is a model specific menu system. The menus in this example appears at the start-up of the simulation run and allows the user to create a new scenario by simply selecting options. Menu items for this newspaper model included options to change machine speeds, truck loading rates, distributions for truck turnaround time and product specific bundle counts. (A bundle of papers is a standard number of pages; however, the number of pages in a paper is determined by the amount of news for the day, the number of papers per bundle will continually vary.) (See figure 4. Start-up Main Menu) The menu system consisted of a main menu with sub-menus for line specific or product specific information. The menu levels were color coded for clarity and formatted consistently to speed the learning curve. By using the menus, it was possible for a non-expert to quickly set up the day to day variations in product data, machine speeds, and operator efficiencies.

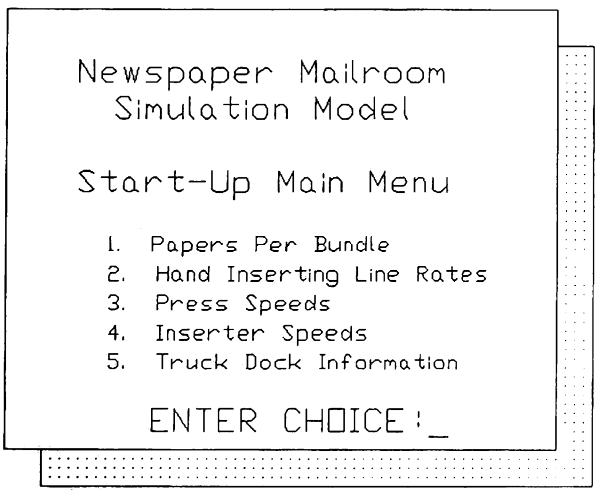

Figure 4: Text Screen: Start-up Main Menu

4.3 Use of External Files

The menus and experiment frame provided the flexibility to easily change the general system configuration. The final element of variation between mailroom systems was the specific truck schedule and production schedule. To keep the model as generic as possible, this information was set up in an external file that was read in at the beginning of a simulation run. The model was designed to read orders in 15 minute blocks; all trucks scheduled for each block would be read in as one event. If there were more trucks than available docks, the model would keep them in a prioritized queue until there was space. The input file also contained the total production requirements of each product. This design feature provided the flexibility to read a schedule with any number of trucks, and any number of product codes with specified volumes. If a newspaper wanted to test existing schedules, they could simply put the information into the specified file format and run the model.

SUMMARY

The value of simulation analysis, a powerful, stand-alone tool, can be enhanced by incorporating peripheral tools and modeling techniques. Debugging, experimentation and analysis processes can all be expedited and clarified by using animation as an aid to the model. When detailed data needs to be displayed in addition to the graphics, dual monitor systems can take advantage of the text screen for output. Future ease of use and satisfaction can be insured by considering the skills of the end user during model design. Non-expert simulationists can be confident users if provided with an interface tool such as a model specific menu system.

Models can be reused for similar systems by developing them with a focus on the generic qualities of the system. Using external files for specific order and production information, will reduce (if not remove) the need to change internal parameters or model statements, and will greatly increase the model flexibility.

By using these peripheral tools in modeling the newspaper mailroom distribution system, it was possible to develop workable truck loading schedules, involve non-experts in the analysis process, and display comprehensive information for experimentation and presentation.

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AUTHOR'S BIOGRAPHY

BARBARA M. WERNER is an Engineer performing consulting and teaching functions for the Simulation Services Division of Systems Modeling Corporation. She received her Bachelors Degree in Engineering from Cornell University, with a major in Operations Research & Industrial Engineering. Barbara previously worked as a Simulation Project Engineer for General Motors Truck & Bus, Central Operations Engineering. At Systems Modeling Barbara has developed a menu-driven tutorial for the SIMAN and Cinema software systems, and has developed and analyzed models of a variety of systems and industries including, high speed bottling processes, AGV transportation systems, ASRS storage facilities, automotive assembly processes, apparel manufacturing, and extensive conveyor systems. Her current interests include developing effective, user interfaces for simulation models. Barbara is a member of IIE and is an active alumni participant in Cornell's high school candidate interviewing process.

Barbara M. Werner
Systems Modeling Corporation
The Park Building
504 Beaver Street
Sewickley, PA 15143, U.S.A.
(412) 741-3727