

AN INTRODUCTION TO PLANNING AND SCHEDULING WITH SIMULATION

Mark J. Sims

Lanner Group, Inc.
31225 Bainbridge Road
Solon, OH 44139, U.S.A.

ABSTRACT

Simulation has proven to be an excellent strategic tool for the enterprise. However, it can also be used as a day-to-day tactical tool on the shop floor, on the hospital floor or in the office. This paper will discuss the inherent difficulty that people face when planning and scheduling and the unique way that simulation can be used to perform realistic planning and scheduling. It will describe a hands-on approach that will help those new to simulation understand how simulation can be used as a planning and scheduling tool.

1 INTRODUCTION

People face scheduling problems and opportunities every day: at the airport, someone is responsible for assigning planes to gates; at a plumbing service, someone is in charge of assigning repairmen to service calls; in a manufacturing facility, someone is in charge of assigning jobs to machines; in a call center, someone is in charge of assigning certain calls to specifically skilled personnel.

Many articles and many software programs have been written that focus on manufacturing scheduling problems. Manufacturing scheduling systems are available on all platforms at many levels of complexity. Simulation-based planning and scheduling systems have proven to be very successful in this area. Simulation, however, can be used in this capacity for more than just manufacturing planning and scheduling problems.

This paper will describe a hands-on approach to help you understand how simulation can be used as a planning and scheduling tool. You will learn how to build a simulation model that can be used for planning and scheduling, and how to use that model to manually produce multiple schedules using simulation. The power and flexibility of using simulation as a tactical tool will be exhibited.

2 PLANNING AND SCHEDULING

It is quite simple to build a simulation model that can be used for planning and scheduling. The main components of the model that you have to define are few. These include:

- When are people, machines, vehicles, etc. available to do work?
- What product needs to be made or service needs to be performed?
- What is the process to make the product or perform the service?
- What resources are required to complete or perform the process (i.e. machines, people, tooling, trucks, etc.)?
- How many parts do we need to make for each customer or what services does the customer need?
- When do they need the products delivered or the services performed?

The last and most important piece of the model is defining the rules that are used to assign work to the resources (schedule) in the model. These rules could be very simple such as:

- Select the task that is due the soonest (Earliest Due Date).
- Select the task that requires the least amount of time to complete (Shortest Processing Time).
- Select the task that requires the least amount of setup time or cleanup time or travel time.

These rules could also be very complex (which is usually the case in the real world) such as:

- Select the task that is due the soonest unless there are any tasks to be completed for Customer A, in which case all tasks for Customer A should be completed first.

- Select the task that uses the same tooling, has the same color, and the same due date as the last task completed by a particular resource.
- Select the task that allows the resource used to be completed or prepared for another task by a certain time.
- Select the resource that best meets all skill requirements to complete the specific task (i.e. speaks Spanish and has an understanding of the employee benefits plan).

As you see, complex rules are very often just a combination of or exceptions to the simple rules. These combinations and exceptions make planning and scheduling a difficult task. However, by documenting/using the rules in a simulation model, the planner/scheduler can be sure that all of the combinations and exceptions are considered and his objectives are met.

It should be noted that the model does not need to be defined using a computer and software. It can be done manually. Many people already perform small simulation runs in their head. When people plan their day in the morning, they often run a simulation of when each task will be started and completed. They make a list of all they have to do today, and then they assign which tasks they will be working on at which times.

For example, one person may decide that completing a monthly report that is due tomorrow (Earliest Due Date) should have the highest priority and thus should be completed first. Another person (who has a similar report to complete) may decide that completing his expense report is the higher priority, because he wants to get reimbursed and he knows that he can get away with handing the report in at least two days late. These simulations can be small and the runs can be short.

Nevertheless, the result is a feasible schedule/plan for the day that meets your objectives. If there is a disruption during the day (unexpected meeting, cancelled appointment, etc.), you can reassess the length and priority for each task and run a new simulation. This same method is also used when running errands. Usually, a person will mentally simulate running all errands in order to find the schedule of events that best meets his objectives. This same method can be used to solve any planning and scheduling problem.

3 MANUFACTURING EXERCISE

The best way to demonstrate how simulation can be used as a planning and scheduling tool is through an example. This example will be from the manufacturing arena, however it could be easily adapted to fit any type of planning or scheduling problem.

In our example we will be manufacturing toy cars. Our facility manufactures three different types of cars

(red, green, and blue) Each car has three parts (a chassis, a body, and trim/hood). Our manufacturing plant has three different stations where the toy cars are assembled (chassis assembly, body painting, trim assembly). Both the Chassis and the Body stations use the same exact scheduling rules, while the Trim station follows a first come first served policy. Figure 1 shows the processing time for each task regardless of the color.

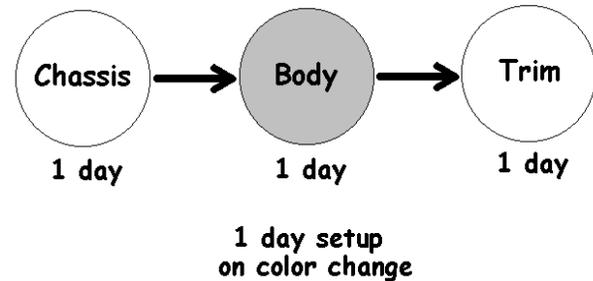


Figure 1: Process Times for Toy Car Manufacture

Our facility has many orders that need to be completed. It is our task to manually simulate the processing of each order through the plant to produce a schedule. In order to see the different results that can be achieved based on the rules that we use, we will run the simulation using four different sets of rules. The rules are simple, but will generate very different results:

- *The Accountant* – In order to maximize revenue, the company accountant has mandated that we run the most profitable orders first regardless of their due date.
- *The Marketing Manager* – In order to maximize on time delivery performance, the company's marketing manager has mandated that we process all orders according to their due date.
- *The Body Station Foreman* – In order to minimize changeovers on the Body Station, the foreman of the Body station has mandated that all orders be sequenced by color, thus ensuring that all like color toy cars are manufactured back-to-back.
- *The Plant Manager* – In order to make everyone happy, the plant manager knows that orders should be scheduled such that all order due dates are met, and where possible the setup time on the Body Station should be minimized. Additionally, since the plant manager does not want to build up excessive work in process, he knows that no new orders should be started if the Body Station has two or more jobs waiting to be processed.

Table 1 shows a partial set of the orders that need to be completed.

Table 1 – Orders to be Completed

ORDER NUMBER	TYPE	DUE DATE	PROFIT
1001	RED	7	750
1002	BLUE	4	1,250
1003	GREEN	8	1,000
1004	GREEN	13	750
1005	BLUE	9	1,000
1006	RED	7	800
1007	RED	17	1,000
1008	GREEN	16	500
1009	BLUE	14	1,250
1010	RED	14	750

If we analyze the order data, we see that the Accountant's rules would schedule many orders to be completed early, while pushing less profitable jobs late. The Marketing Manager's rules would facilitate the need for a lot of setups. The Body Station Foreman's rules would reduce the setups to only two days, but in the push for efficiency, many jobs would be completed late.

Which of the rules sets gives the best schedule? We should realize that it depends on what the objectives and goals are for the plant. As the above rules show, the best schedule for the Accountant may be the hardest one for the Body Station Manager to execute or the one that is least acceptable to the Marketing Manger.

As each schedule is generated, we should manually create a planning board or Gantt Chart, as well as collect key statistics about the model such as machine utilization, on time delivery performance, total throughput, total profit, etc. This will help us analyze the simulation results. By comparing the results, from each set of rules, we will see the value of using what-if analysis to determine the best way to schedule the facility. In other words, we can produce four different schedules based on the four different sets of rules given to us, and present which schedule is best in all of the categories.

Note that all of the simulated times used in the above example were deterministic. In order to produce a feasible schedule for the plant, we would need to use the average setup time and run time. We know that there will be some variation from the average times, but as schedulers, we do not want to try to predict the randomness of the process time. The use of stochastic data would give us a long range, strategic model that could be used look at our future capacity needs. For day-to-day operation, however, the deterministic tool will give us a realistic schedule.

4 SERVICE EXERCISE

We could easily create a similar exercise that exhibits how simulation-based scheduling can be used to allocate resources to assignments. These resources could be repair men that need to perform service calls. The service call has requirements that can only be met by certain resources with the necessary skills. Our exercise might allocate repairmen to service calls. Each service call will have a certain skill set required and each repairman will have a skill set. The objective would then be to assign a repairman to each service call. In addition to just matching up skill sets, the rules of assignment might also consider the revenue brought in by the service call, the hourly cost of the repairman, the distance to the service call, the length of time that the service call might take, the amount of overtime the repairman has already worked, etc.. Again, we could create a planning board that shows the schedule for each repairman and key statistics could be collected such as total distance traveled, total cost, total profit, number of service calls completed, etc..

Additional events could be added to the exercise that would demonstrate how a day-to-day simulation-based planning and scheduling system is used to react to random events such as a vehicle breakdowns, cancelled service calls, emergency service calls, etc..

SUMMARY

Simulation can be used as both a strategic and a tactical tool. Even though manufacturing has been the main area where simulation-based scheduling tools have prospered, it could be used in many different areas. This paper outlined a hands-on approach to understanding simulation-based planning and scheduling. It can be very helpful to those new to simulation understand the methods that are used by simulation-based schedulers.

AUTHOR BIOGRAPHY

MARK J. SIMS is a Technical Consultant for the Lanner Group, a leading developer of simulation-based decision support tools. He is primarily responsible for managing finite capacity planning and scheduling installation projects. He received a B.S. in Industrial Engineering from the University of Michigan in 1992, and an M.S. in Industrial Engineering from Cleveland State University in 1996.