DISCRETE EVENT SIMULATION

SIMULATION PROJECT

Gülgün ALPAN, Maria DI MASCOLO, and Siao Leu PHOURATSAMAY *Master SIE*

The market for garden dwarfs are in full expansion in France for the last decade. Directly faced with this market explosion, "Magical Lantern", a leading company in garden dwarfs, elfs and gnomes production in France, is willing to audit his production process and eventually invest on possible improvements which can guarantee the company to cope with the increase in customer demand.

Today, the demand is around 1000 garden dwarfs per week, and it is expected to overpass 1100 in a short period of time. And finally a current study indicates that the market will continue to grow and the demand will exceed 1250 garden dwarfs per week by the end of the year.

Magical Lantern is currently capable of satisfying the demand. However, the top management has some serious concerns on the production capacity as it comes to 1100 units per week.

You are currently doing your internship at the company and the managers count on your industrial engineering skills. You are summoned to study the production system of the company in order to anticipate the increase in demand.

1 Description of the production unit

1.1 The products

The production unit under study is a dedicated production line, used only for the fabrication of a basic electronic garden dwarf. The only diversity is obtained by different colors of the model. This model is equipped with a lantern which turns on automatically by the nightfall and turns off after a certain duration which is programmed by the user. The major components of the product is as follows: a garden dwarf made of non painted plaster, an electronic chip which enables time programming features, electrical cables and a lantern.

1.2 The production system

The company receives the raw garden dwarfs from a supplier by pallets of 100 units. The pallets are received at the inbound docks and are transferred to a storage area next to the painting shop.

The painting shop can only handle a single raw garden dwarf at a time. The dwarfs are then automatically transferred in a drying tunnel which is equipped by a conveyor. The drying operation takes 8 minutes. At the end of the drying tunnel, 100% of the products are controlled. According to the reports of an earlier kaizen group, 5% of the products are scrapped since they do not satisfy the quality standards of the company and 10% are sent back to the painting shop for a rework. During the first passage, the duration of painting follows a normal distribution with a mean of 1 minute 50 seconds and a standard deviation of 20 seconds. For the products which are reworked, the mean is only 1 minute 30 seconds and the standard deviation is 30 seconds. After this quality control point, the accepted products are temporarily stored waiting to be polished.

The polishing is done by a numerically controlled (NC) machine which can treat a single unit at a time. The polishing takes 1 minute 20 seconds for each unit. This NC machine is rather reliable but breakdowns may occur occasionally (MTBF: exponential with a mean of 2 hours, MTTR: exponential with a mean of 4 minutes). The products are then routed via an intermediary storage to the electronic chips assembly shop.

This phase of the process consist in assembling a garden dwarf and an electronic chip retrieved from a stock. This operation follows a triangular distribution with the following parameters: 1mn30s,2mn6s,2mn25s. The chips are produced in a neighboring workshop. After the assembly, the product is put in a temporary storage and wait for the wiring operation.

The wiring operation requires some preliminary preparations. Raw cables are delivered and stored. They are then cut in shorter lengths and fixed together to obtain bundles to be wired up on the product. The wiring operation, completely manual, is performed by operators as soon as the components are available. This operation being critical, operators of other workshops are immediately called if components are waiting and nobody is available to carry out the operation. So far, no in-depth studies have been conducted on the wiring processing time. Some data has been collected which reveals that the processing time varies between 50 seconds and 1mn30s. The collected data is available on the collaborative database of the company (download wiring_data.txt from Chamilo). After the wiring operation, the products are placed in a storage before being sent on a conveyor belt for the assembly of lanterns and other small accessories.

The assembly of lanterns requires 3 serial operations and is realised by 3 operators who are positioned along a conveyor belt. The conveyor belt is 30 meters long. It is divided in 3 zones and moves with a constant velocity of 0,6km/h. The dwarfs are placed on the conveyor belt, by respecting at least 1 minute 50 seconds between two consecutive dwarfs in order to leave enough time for the operators to complete the assembly operations.

1.3 The management of operations

The factory is open 8 hours per day, 5 days per week (except for the weeks with holidays). The factory is closed during the first 2 weeks of August, as well as the week between Christmas and the New Year's day if these days are not on a saturday or a sunday.

In order to have a good coordination between different phases of the production, some lean management tools have been put in place. The procurement of the raw garden dwarfs are managed by a kanban. A kanban is attached on each pallet of 100 dwarfs. As soon as the dwarfs are unloaded, the kanban attached to the pallet is removed and sent back to the supplier. The delivery lead time of the dwarfs is fix and equal to 2 days. The number of kanbans is fixed at 20 based on a prior study.

The production manager wanted to control the work-in-process inventory inside the production unit and hence, a general kanban is installed. The raw garden dwarfs are sent inside the production unit one by one and only if there is a kanban available at the entrance. If a kanban is available, it will be attached on the garden dwarf, and will stay on until the product arrives to the outbound dock. There, the kanban will be removed from the product and sent to the entrance of the production unit. The number of kanbans to control the W.I.P. is fixed at 50.

Similarly, another kanban system has been put in place, in order to assure a good coordination between the workshop in charge of the production of the electronic chips and the dwarf assembly line. A kanban is sent to the electronic chips workshop as soon as a chip is taken from the stock to be assembled on a garden dwarf. A prior study has shown that the time for a kanban to reach the chip fabrication workshop, plus the production setup and the transfer of electronic chips to the dwarf assembly line do not vary much and can be considered as a fix duration of 40 minutes. On the other hand, the chip fabrication process depends highly on the amount of earlier orders to be processed and may vary between 3 and 37 minutes. The number of kanbans at this stage of the production is 26.

The cables are procured in big quantities. A safety stock guarantees that there is no stock outs. The cables are first cut into shorter lengths. The cutting operation takes 30 seconds per bundle. They are then stored in a temporary storage waiting to be prepared. The cabling workshop is operated such that this temporary stock is never empty. The bundles are prepared uniquely on order. An order of 300 bundles is sent out when the finished bundles stock is below 60 units. The order is fulfilled in lots, hence the lot of 300 will be sent to the finished bundles stock when all 300 are prepared. The bundle fabrication time is 2 minutes and 5 bundles are prepared in parallel.

The production of lanterns are subcontracted. They are delivered every morning before the first shift starts. The orders are sent out by EDI, the night before and after the final shift is over. The quantity requested is calculated using the order-up-to level policy. Based on the remaining lanterns in the inventory, a quantity to complete the stock upto 300 lanterns are ordered.

2 Description of the demand

The department of customer relations has recently collected a lot of data to update their demand forecasts. Below is the main results of the recent analysis on the collected data:

- An order is characterized by a lot-size and an order inter-arrival time.
- The lot-sizes vary between 5 and 45 dwarfs and seem to be uniformly distributed (see order_lot_size_data.txt). As soon as an order arrives, the department of delivery checks the finished goods inventory. If there are enough dwarfs available in the stock, the order is prepared and sent out immediately. Otherwise, the order is assigned a "wait" status and will only be fulfilled as soon as the stock level reaches the lot-size required by the order.
- The time which separates two orders can be modeled by a normal distribution. At the current operating conditions, the parameters of this normal distribution is estimated to be a mean of 1 hour and a standard deviation of 10 minutes. However, in a short period of time, the mean is estimated to diminish to 54.5 minutes and finally reach 48 minutes in the long term. The standard deviation is estimated to be stable at 10 minutes.

Besides the data provided by the customer relations office, the production manager provides you with the results of the production over a period of 10 weeks. These 10 weeks correspond to a period when the factory was working upto its maximum capacity to build up stocks to face the upcoming demand increase. The number of garden dwarfs produced per day is given in table 1.

Day	Prod.	Day	Prod.	Day	Prod.	Day	Prod.	Day	Prod.
1	212	11	212	21	207	31	207	41	208
2	207	12	206	22	208	32	212	42	205
3	209	13	206	23	209	33	213	43	207
4	207	14	209	24	208	34	205	44	212
5	207	15	208	25	205	35	206	45	205
6	208	16	210	26	212	36	209	46	211
7	210	17	209	27	213	37	208	47	208
8	206	18	208	28	204	38	212	48	204
9	208	19	211	29	211	39	207	49	207
10	204	20	207	30	203	40	205	50	203

Table 1: Production over 10 weeks

3 The first mission

You are asked to study the system via simulation and propose modifications so that the increase in future demand can be faced. The modified system should progressively be able to produce 1100 and then 1250 garden dwarfs per week.

To conduct this simulation project, follow the guidelines that you have learned during the simulation lectures.

4 The second mission

As soon as you have completed your first mission, you have presented your results to the board of directors of the company. They have informed you that in an earlier meeting, they have decided on a customers service level. They are willing to extend the perimeters of the current study so that this decision can also be considered. Hence, you are asked to take into account this new performance measure and integrate it into your simulation model. The board of directors would like to know if the production system can guarantee that no more than 1% of the orders are delayed due to the stock out of the finished products. If this objective cannot be satisfied, you will be proposing new modifications on the system to achieve this goal.

5 Expected Reporting

You are asked to return in 2 reports

- A "**written assumptions report**" (**deadline Wednesday, March 22, 2023**) which should include:
  - your conceptual flow model
  - your simplification assumptions, with their justifications *(bottlenecks, statistical analysis of the data sets which are on Chamillo, and other calculations - details can be put in appendices)*
  - the final process flow model, obtained after making all the simplifying assumptions - *it is this model that you are simulating with ARENA.*
  - the performance measures that you are willing to study
  - all other relevant information in your written assumptions document.
- A **final report** (**deadline: Wednesday, May 17, 2023**) that conveys all related information to the managers in order to convince them on the improvements that you are proposing. Therefore, the final report should include (besides other information that you judge essential):
  - the explanation of your modeling choices
  - the model validation
  - the explanation on how you calculated your simulation parameters settings *(Warm-up period, number of replications and replication length)*
  - your experimentation parameters
  - your analysis of the results *(you must base your analysis on the simulation output)*
  - Proposed improvement scenarios and a in-depth study of the impact of these improvements on the system performance measures. *For these improvement scenarios, you can propose any change in the system, provided that it is realistic and you explain how you could achieve it (for example, you cannot just say : I increase the capacity of a machine, but you can for example add a second machine to increase the capacity of the operation). Of course, you have to observe the impact of the proposed improvements on the production capacity, but also on the other performance parameters, that may be degraded, or also improved*
  - Your conclusions and suggestions *(which scenarios do you propose to implement? why?)*

  Every information you convey should be justified either by theoretical or experimental means.

You also need to send your **ARENA codes** (.doe). Please name them as follows:

- Student1Name-Student2Name-Student3Name1000.doe (for the ARENA code corresponding to the actual state of the system),
- Student1Name-Student2Name-Student3Name1100.doe (for the case where you propose improvements to increase the production capacity to 1100 dwarfs)
- Student1Name-Student2Name-Student3Name1250.doe (for the case where you propose improvements to increase the production capacity to 1250 dwarfs)

  Eg: If we were to do the project with Gülgün, we would have named our file Alpan-DiMascolo1000.doe