SIMULATION OF THE DESIGN AREA IN A PRINTING COMPANY

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ABSTRACT
This document presents a study of the activities in the Design area of a company devoted to the printing of promotional products, then the process is simulated to analyze the performance of the area and, with the help of this simulation alternatives were assessed with the aim of determining its ability to respond to customers once they have placed an order. The document begins with an introduction to the activities done in this area, followed by definition of the problem and then we present the methodology followed by the Simulation Model built in Simio and afterwards show the results. Finally we give some conclusions about the activities in the design area.

Keywords: printing design, simulation, printing company (Graphic arts)

1. INTRODUCTION

The Company where this project takes place, prints promotional products, using printing techniques such as silk screen, pad printing and laser engraving, the main products customers request are: pens, keyrings, cups, thermos, among other things.

Table 1: Main products and the printing technique used

No.	Product	Printing technique
1	Pens	Silk screening
2	Metal keyring	Laser engraving
3	Stress Ball	Pad printing
4	USB Memory	Laser engraving
5	Cylinders	Silk screening

The customer/salesperson sends a sketch of the logo that the customer wants printed, through a web system, the DO (design order) that consists of a dummy, the designer is responsibility for checking that the logo has the correct form, in other words the image must be in (vectored) Curves so that will not be distorted during the printing process, it is also necessary to check the logo's position on the product it is to be printed on, as well as its dimensions and the colors of the ink used. Once these activities are completed the dummy is returned to the customer/salesperson for their approval. If approved, an invoice is made out and the DO goes to planning, the dummy is used to make a positive or negative depending on the printing technique, and if the customer requires any modifications the DO is brought back to the design area for the necessary changes to be made and it is sent back to the customer/supplier, until it is accepted.

Figure 1: the main products handled by the company

The Design area has three workers (designers) who work from 8 am to 5 pm, as well as an intern who works just four hours a day from 8 am to 12 pm, the web system can even receive DOs outside the designers' working hours, so the queue of DOs can increase from one day to another because of the DOs received outside working hours.

The designers must know about the printing techniques they use, the different types of inks they have and which ones can be applied to which product, and they must also be able to handle graphic design software such as Adobe Illustrator (AI), all of which they need to do their work to the best of their ability and to advise the customer on the job they require

2. PROBLEM DEFINITION

The following research questions were designed to be used as a guide during the study:

- Is there enough capacity in the Design area to deal with the demand of DO customers?
- What is the average time a customer/salesperson must wait from the moment they send their DO through the web system until the designer returns it to them for authorization?
- What response time can the company establish, as a customer service policy, for returning the DO for authorization once it has been uploaded onto the system?

The scope of the research is confined to the activities of the designer, tracking the DOs from the moment they are received in the system until, once authorized, they are released into planning.

The designers' working hours are from 8 am to 5 pm with an hour for lunch; although outside of this schedule the DOs could be waiting in line owing to the fact that the system is still open and could be generating DOs.

Table 2: Designer's job description

Graphic Designer	
Main Objectives	Activities and/or duties
To communicate a certain message, a message prepared by a person and aimed at a specific context, linked to a selection of elements, colors, shapes, typography selected for the graphic communication of the printed message on a product	To download the dummy template from the system. To review the product's specifications. Vectorization of logotypes. The dummy is filled in as per the design order and is uploaded to the webpage for its revision and/or authorization. Revision of email to see whether the DO has been authorized or needed to be corrected.

The designer may have other activities such as the creation of positives or negatives that shall not be taken into account for this study.

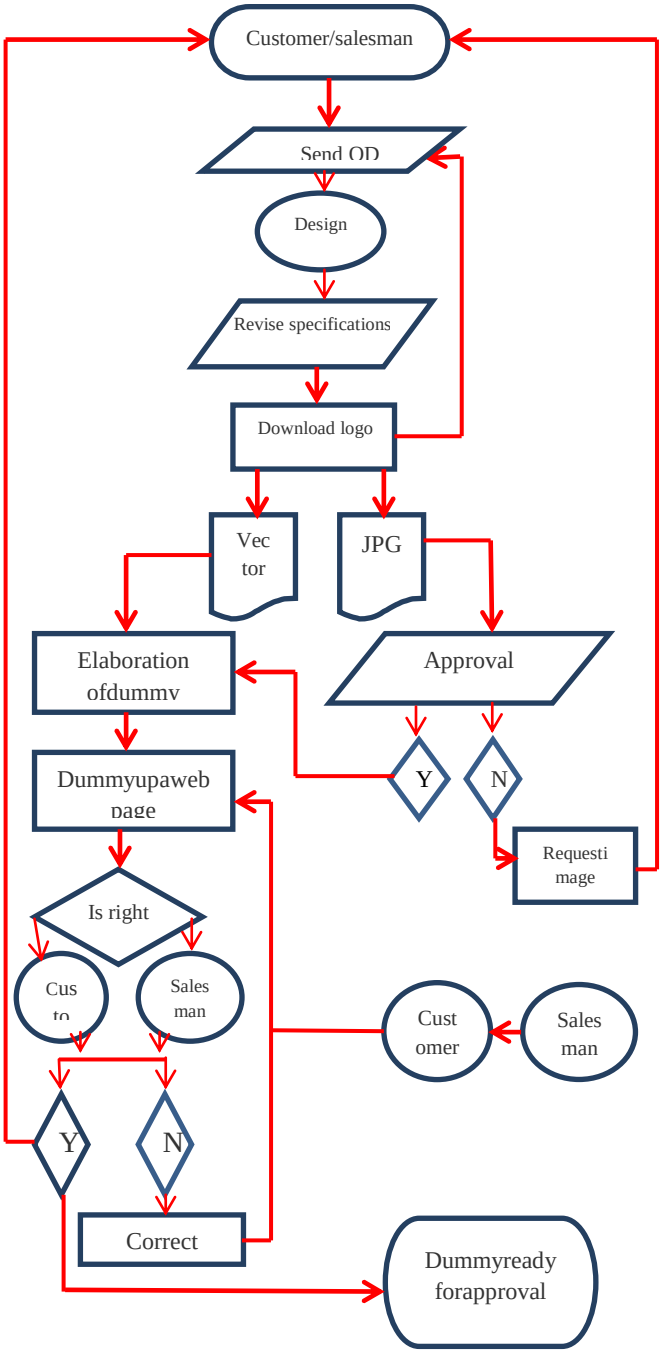

Figure 2: Flow diagram for the design area

The objective is to get the descriptive steps of the performance of the Design area through a simulation study that models the DOs' waiting times in the system, from the moment the designer begins to work on the DO until it is authorized by the customer/salesperson as well as to assess some of the scenarios of interest in order to establish a policy for responding to the customer.

3. METHODOLOGY

We carried out the research in the order followed in the methodology given below (Flores, 2006):

3.1. Problem definition

Here we determine the general objective as well as the specific aspects of the research, the scope and the resources needed.

3.2. System conceptualization

Once we had defined the problem to be researched, we determined the aspects or factors that are most important and most influential in the phenomenon, in order to decide whether or not to include them in the model and in how much detail.

3.3. Data collecting

Once we had conceptualized the system, we determined whether or not the available information was reliable and what other information was needed, in accordance with the requirements of the model.

3.4. Model formulation

Simio software was chosen for the simulation, because of its robustness and ease of use. A model was built that incorporated the previously defined relevant aspects.

3.5. Verification and validation of the model

Some tests were done to find and correct the errors of logic in the model and other tests were implemented to ensure that the results of the model continued to correspond to the real system.

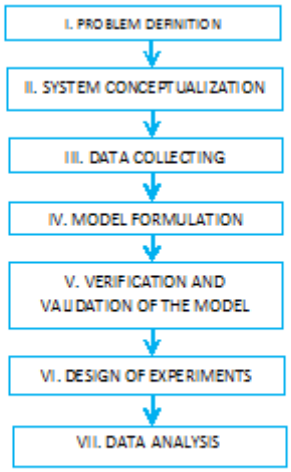

Figure 3: Methodology Followed

3.6. Design of experiments

In this section we defined scenarios of interest in accordance with the objective of the research.

3.7. Data analysis

Here the obtained results are compiled and some conclusions given on the present functionality of the system.

4. SIMULATION MODEL

4.1. System conceptualization

The elements relevant to model our study system are: the webpage where the customer and/or the salesperson uploads the DO which must contain the necessary information for the designer to make the dummy, information such as the logo, its dimensions and the substratum where the printing will be done, as well as the tone of the tint that will be used.

The designers take the OD and make the dummy which is a sketch of the final product, this is sent back into the system for the customer's/salesperson's authorization, if it is approved the designer will send it to Planning, otherwise the necessary changes will be made until it is authorized.

In planning the product's manufacturing is programmed this depends on the characteristics of the product and the technique that will be used to do the printing.

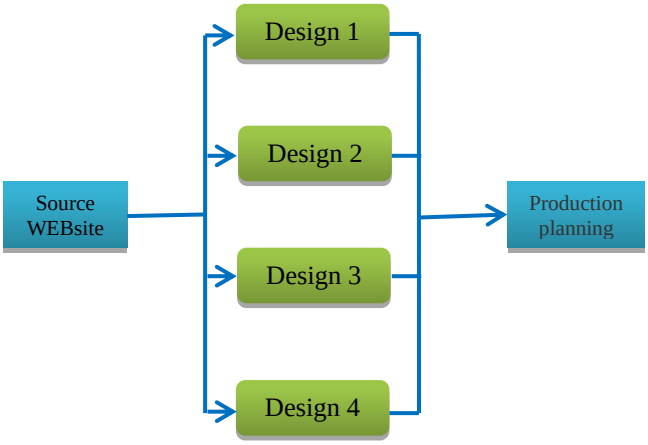

Figure 4: System conceptualization

4.2. Data collecting

The data collection was done in two ways, the first directly from the webpage where the moment a DO is uploaded the date and time are automatically saved, an important factor to mention here is that the page stays available to upload DOs outside the designers' working hours which is from 8am to 5 pm. Which is why in one

day the DO queue is made up of the unfinished ones from the day before more than the ones uploaded after 5p.m. and the ones accumulating during the shift. The working days are from Monday to Friday, if a DO is entered into the system on Saturday or Sunday it is considered as though it were entered on Monday at 8:00 am.

Figure 5 shows the DO data collection stage. In 37 consecutive working days 1550 DOs entered into the system, for a λ of 41.9 DOs a day.

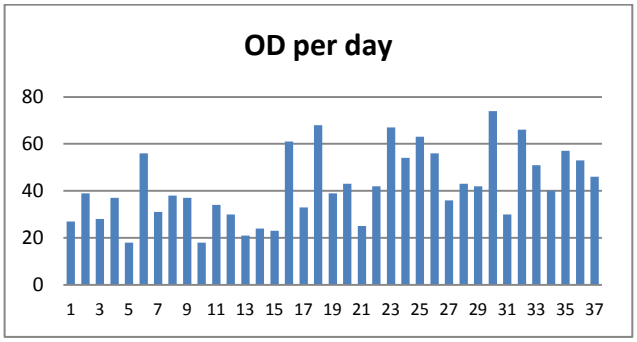

Figure 5: DOs entered per day

The second part of the information was taken directly from within the design area; there are four designers, three of them full-time workers and an intern that only works half a work day. Kenett and Shelenyahu (2000)

4.3. Model formulation

The model will be built as a system with a source that generates the entities (DO), which may be of two types, the ones that arrive with a logo that has already been vectored and the ones that bring it in an image format.

The entities automatically enter the queue, any of the servers (designers), if available, can access the system and download the DO according to FIFO policy, and work on it until it has been authorized to send to planning and thus leave our system under study.

The μ service rate will be analyzed as a whole for all the servers and individually, as their work experience affects their service time.

As we have already mentioned, the software we chose for the simulation is SIMIO. Kelton et al (2012)

The following objects were used:

4.3.1. Entities

As was already mentioned, two type of entities were used. The DO that come with the logo already vectored and the ones who bring it in an image format, the designers need to spend more working time on the latter owing to the fact that that they have to vector the image so that it will not be distorted when printed.

4.3.2. Sources

We used a source that generates the entities (DO), which symbolizes the webpage where the customer or the salesman upload the design orders.

Said source must generate two types of entities, the ones that represent the vectored images and the ones that arrives in image format.

Table 3. Arrival Rate of DO per day

Week	Amount	λ	Classification
1	151	30.2	Medium
2	178	35.6	Medium
3	142	28.4	Low
4	242	48.4	High
5	187	46.75	High

4.3.3. Servers

There are four servers, that correspond to the designers, each of whom has their own work station (desk, phone and computer equipment) where they do their work. When one of them is available they enter the webpage and take a DO under the FIFO discipline. The service time of each designer varies depending on their skill and experience in the job.

4.3.4. Sink

A sink is an object that destroys the entities, in this case we only used a sink to destroy the DOs once the design process had ended, in other words, once the DO has been authorized and sent to the planning area.

4.3.5. Paths and Nodes

The Paths were used to determine the DOs' path within the system and the nodes to represent the points where the DOs are taken by one of the four designers. For example, the paths that come from the DOs source have a node that represents the decision to select a different designer (D1, D2, D3 and D4). The probability of going with one of them, considering a similar service rate for each of them is such that:

$$e_1 + e_2 + e_3 + e_4 = 1 \quad (1)$$

Below are some of the images of the simulation model:

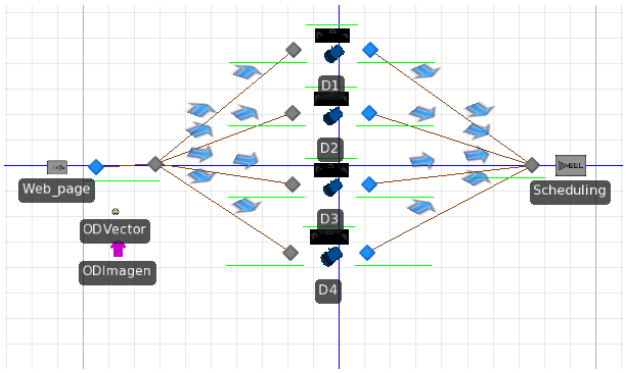

Figure 6: Simulation with SIMIO

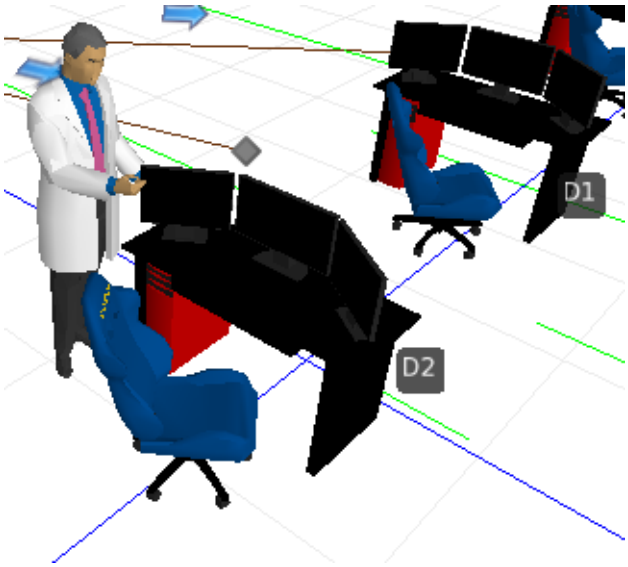

Figure 7: Work area, Designer 2

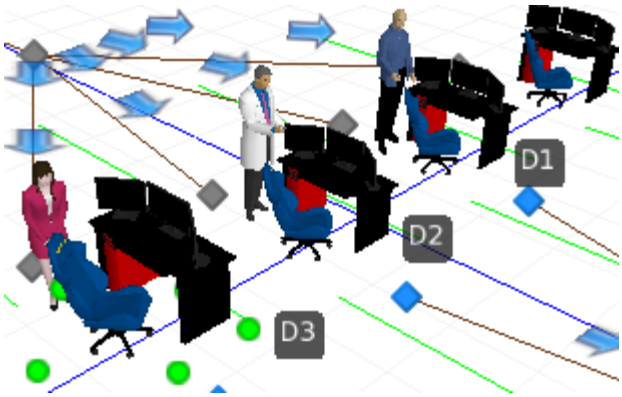

Figure 8: Simulation with 3 designers

4.4. Verification and validation of the model

To validate the model we used the following techniques:

4.4.1. Comparison with the real system

A simulation was done on the number of DOs going into the system, using real data taken from the system after having made the model, then the quantity of these DOs that were dealt with by the designers was compared with the results obtained in the real system and the results were very similar.

4.4.2. Behavior in extreme cases

A simulation is done with a significant input of DOs and a large backlog on the queue, as has occurred on several occasions in the real system, with similar results.

In another test, there was a significant drop in input of DOs in the system, here the results varied in respect of the real system, in which there was an increase of service time on the part of the designers. Law and Kelton (2000)

5. DESIGN OF EXPERIMENTS

5.1. Scenario 1. Normal operating conditions

A simulation is done of the system with the current working conditions, considering an individual service rate for each designer and the input of DOs, which varied over time, as shown in table 3.

The aim is to learn the system's performance measures under normal conditions.

5.2. Scenario 2. With only three designers

In this scenario one of the designers is not working, due to incapacity or absenteeism, which tends to happen fairly frequently in these types of companies. Here an equal service rate is considered for designers at work.

The aim is to determine the impact on the system of working with one less designer, since one of our aims is to find out the company's customer response time.

5.3. Scenario 3. Trained designer 3

In this instance, we consider the case of the designer with the lowest service rate having been trained to do his work better and achieving an average service rate

The purpose is to determine the possibility of lowering waiting time in the DOs queue by increasing the designers' average service rate.

5.4. Scenario 4. Same type of DOs

Here we consider a scenario where the DOs entered into the system are all the same type. Currently the DOs are entered either with a vectored logo or with a logo in an image format. With the former ones the designer takes on average a little more than double the time taken with the ones already vectored, (approximately 12% of the entered DOs come in an Image format)

The aim is to assess the impact on the response time by reducing the percentage of DOs, currently 12%, in image format.

This following table gives a summary of the above scenarios:

Table 4. Table of scenarios.

Scenario	Description
1	Simulation with normal operating conditions
2	One of the designers is absent from work, so only 3 servers are considered
3	The designer with the lowest service rate is trained
4	The same type of DOs (vectored) are considered

6. RESULTS

A simulation was done for each scenario considering a period of eight hours work, ten replicas of each experiment were made. This was repeated for each scenario.

The results are given below:

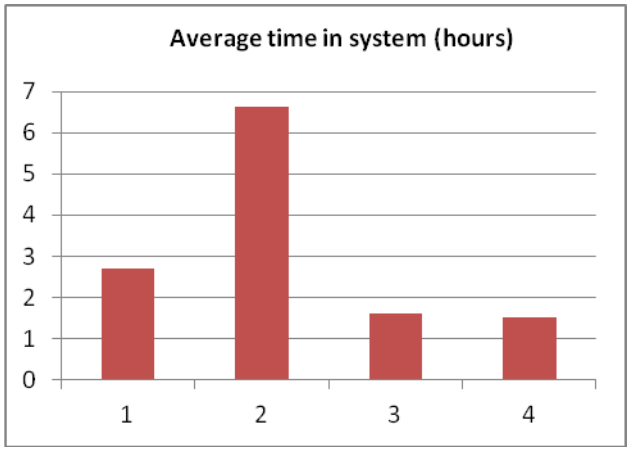

Figure 9: Average Time in System

The average time in the system is 2.71 hours under the present conditions. When a designer is absent, the average time increases by almost seven hours, meaning that there will be DOs pending at the end of the shift (scenario 2). In scenarios 3 and 4 the time is reduced by approximately an hour, meaning that increasing the service time of the least able designer would be almost the same as if the customers were to send all their logos vectored.

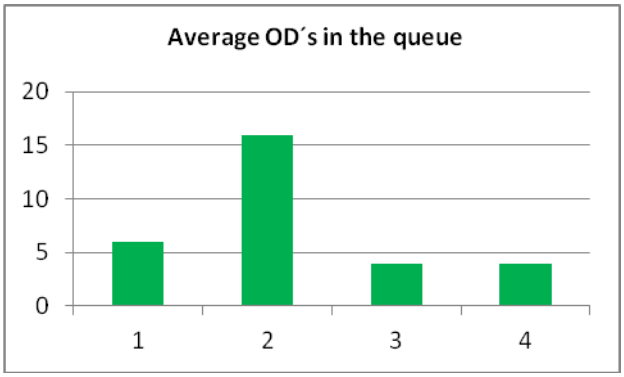

Figure 10: Average DOs in queue

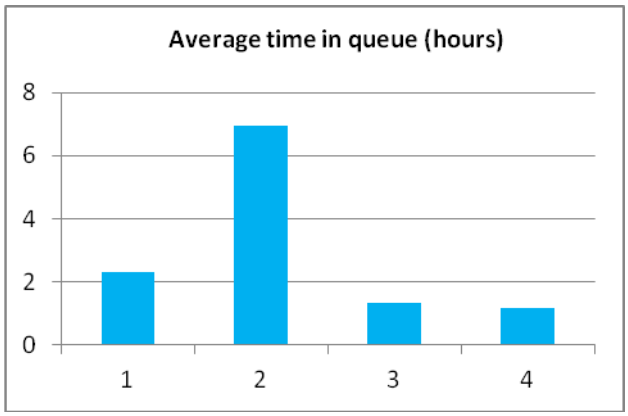

Figure 11: Average time in queue

The average of DOs in the queue increases considerably when a designer is absent, this implies that their time waiting to be done also increases (scenario 2), and the behavior is similar for both scenarios 3 and 4 where, in comparison, we would decrease by approximately the same amount.

7. CONCLUSIONS

This study served to see the impact the designers' work has on the DOs carried out.

With the results obtained we can carry out an analysis to evaluate if the company should decide on a response policy in releasing the DOs to their customers, and, as can be seen in the results, if a policy of no more than three hours response time is stipulated, this would be accomplished as long as all the designers turn up for work, because otherwise the response time increases to approximately seven hours.

If the designers' average service time were to diminish or if they were only received vectored DOs, the response time would be two hours less.

Reformulating the research questions gives us:

- Is there enough capacity in the Design area to deal with the customers' demand for DOs?

Yes, the Design area of this company has enough capacity to meet the customers' demand for DOs.

- What is the average time a customer/salesperson must wait from the moment they send their DO through the web system until the designer returns it to them for authorization?
  Under the present working conditions, it takes almost three hours for the design area to return the DO for authorization.

- What response time can the company set, as a customer service policy, for returning the DO for authorization once it has been uploaded onto the system?
  Maximum seven hours. If one wants to lower this customer response time, some of the following recommendations could be taken implemented:

Train the designers that take the longest to release the DOs, as this would make the average service rate less. The cost of training could be recovered by doing a greater number of DOs in same time.

Asking customers to deliver their logos already vectored rather than in an image format, although this could cause discontent among some customers who might change their supplier and withdraw their orders as a consequence.

Training another worker to do the work of a designer in case any of them is absent for any reason, especially in the case of an incapacity that lasts for several days.

Making the designers aware of the problems they cause when one of them is missing or slow at their work.

And lastly, studying the characteristics of this department's physical space as while we were collecting the data we noticed some distracters that have an influence the designers' work.

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