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USING SIMULATION TO CHOOSE BETWEEN RENTAL CAR LOT LAYOUTS

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1 ABSTRACT

This paper presents a flexible, rental car lot simulation model. This data-driven model serves as a template that can be used to easily test configurations and options used in the real system. The advantages of this simulation model as an analysis tool and the knowledge Avis learned as a result of simulation analysis are presented.

1 INTRODUCTION

In the rental car industry, the number of cars that are waiting for or currently in the process of being cleaned directly translates into unrealized potential income. Although the actual time spent preparing a car for rental (e.g., cleaning, servicing, and fueling) can not be significantly reduced without affecting quality, the number of cars being prepared at a time can be modified. Of course there is a cost involved with any improvements to accomplish this.

The simulation project was initiated to analyze various lot layouts proposed by Avis. These layouts would modify the route that cars take as they get returned, fueled, serviced, and washed. The goal was to provide an accurate examination of how these layouts performed with a given set of input parameters, then to modify the parameters in order to determine the maximum capacity of each proposed layout. Case study scenarios would be used to test how parameters such as lane filling algorithms for the check-in lanes, the minimum desired level of cars ready to be rented, the number of scheduled rentals and returns, and employee schedules would affect the defined outputs.

Avis also defined the statistics that they were interested in studying. In addition to the capacity of each layout, the walking times for customers and agents, agent utilization, and vehicle driving times would also be ascertained. This information was written to a custom report that could be read by any text editor and analyzed.

2 BACKGROUND

From the point of view of a rental car company, there are three essential processes that occur in a rental lot. The first process details how the customer is handled during the time spent checking out a vehicle. The second process is what happens while a customer checks in the vehicle. The third operation, which is hidden from the customer, is what happens to a vehicle between being parked in the check-in area by a customer and being checked out by another customer.

Each of these processes have their own operations and priorities. During the two phases involving customers, the primary goal is the satisfaction of the customer. During vehicle preparation, there is a minimum amount of time required to be spent on each car in order to assure a certain level of quality. The goals in these areas are to minimize the amount of time vehicles spend moving or waiting unnecessarily. What follows is a brief description of each process that occurs in the rental car lot.

2.1 Customer Check-out

Two types of customers enter the simulation via bus: regular and preferred. The bus drops off preferred customers at their vehicles, then continues to the office where the regular customers are dropped off. The rate at which buses arrive at the lot is determined by a combination of the number of bus drivers available and the desired inter-arrival time. These parameters are both read in from an external file. The numbers of preferred and regular customers are also read in from a data file, and are based on a fifteen-minute incremental customer count.

After a customer checks out a vehicle, the customer drives to the guard gate. There is a short delay before the customer leaves the lot and exits the simulation. The number of exit lanes and the amount of time taken for the delay are both read in from an external data file.

2.2 Customer Check-in

Customers have two options when returning a vehicle. They can park the vehicle and go into the rental office to check the car in, or they can check in the vehicle in the parking lot with the assistance of an agent referred to as a rover.

The number of customers that are checking in a vehicle during each fifteen-minute interval and the number of those customers that use a rover are read in from a data file. Keeping this data in a file allows the simulation user to quickly change the input data to match any given day and perform an analysis

When checking in, the customer drives the car to the most forward location in the check-in area based upon which filling method is indicated in an options file, which is modified by the simulation user outside of the model. After pulling the car forward, if the customer is going to be checked in by a rover, they will wait for one to check the vehicle in. Otherwise, they will immediately travel to the rental office and check the vehicle in with the assistance of a rental agent. After checking the vehicle in, the customer will travel to the bus stop, where they wait for a bus to pick them up. The simulation is not concerned with the customer after they get on board the bus.

2.3 Vehicle Handling

After a vehicle gets dropped off by the customer and checked in, it then needs to be fueled, serviced and cleaned. The rovers are responsible for pulling cars forward to the service stations to be fueled and serviced. After being serviced, the service agent pulls the car forward to a parking area in front of the car wash.

Slotters are responsible for washing the car and parking it in the next ready location. The location selected will be either preferred or regular, based upon the current number of cars in each area and the desired vehicle level for that area. The vehicle will then be parked at the location closest to the office for the selected area.

Each of the delay times taken as a vehicle gets prepared is based upon parameters read in from a file that can be modified by the user. In addition to this, there are other parameters which modify how the ready lines are filled with clean cars, and how many cars must pass through the maintenance area before being cleaned. The maintenance area is not modeled in detail, and it is assumed that during a typical eight hour shift, the maintenance crew can replace or fix every car that was rejected during the previous day.

Each evening, the rental lot will tally up the number of cars required for the next day's rentals. If there are not enough cars on the lot to handle the rental requirements, and there will not be enough cars returned to make up the difference, dirty cars are brought in from a nearby site. For simulation purposes, these vehicles are created at midnight.

3 CASE SCENARIOS

Avis initially had three potential lot layouts that they wanted to analyze. The goal was to determine which layout was the best based on the given parameters. These were to be compared to the original layout at the given schedule rates. These layouts all used the same ready lines, car wash, and check-in areas as the original lot (shown in Figure 1), however, the number of service stations and the location of these stations were varied.

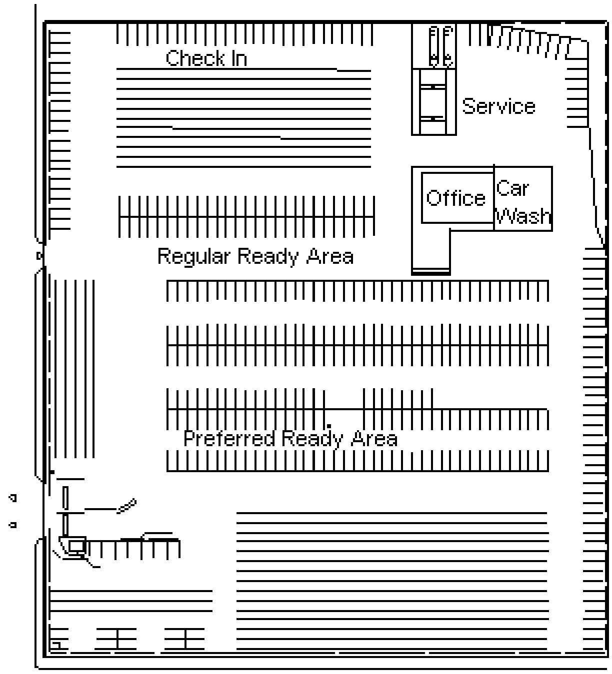
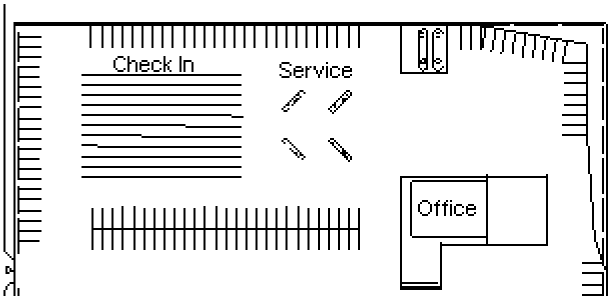


Figure 1: Original Layout

Every proposed layout increased the number of service islands from two to four. This gave eight service locations at which vehicles can be fueled and serviced. The layouts also varied the number of check-in and parking locations. The layouts used the same number of employees for initial capacity comparisons, and left the office location unchanged.

The first layout had the four service islands oriented at a forty-five degree angle relative to the vehicle direction in the check-in area. These service islands are positioned farther away from the office then the original model to allow for more vehicles to park between the service islands and the car wash (called the pre-wash area). Figure 2 shows the positioning of the service locations for the first layout.

The second layout also has the service islands at a forty-five degree angle. However, this layout has its service locations placed much closer to the car wash. This expands the check-in area, but creates a smaller pre-wash area in which cars can wait. When the lot was busy, the smaller pre-wash area would back up into the service island, causing work stoppage.



Firgure 2: First Optional Layout

The third layout has the service islands in a single row. The single row layout takes less room then having the islands diagonal. This allows for more area to be divided between the check-in area and the pre-wash parking area. The disadvantage of this layout is that six parking stalls are unusable in the regular parking area (see Figure 3).

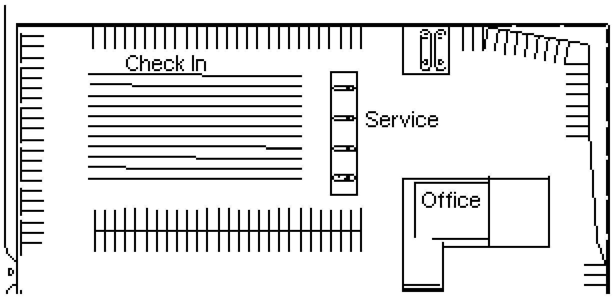


Figure 3: Third Optional Layout

After some analysis was performed on these three layouts, a fourth layout was proposed. This layout moved the check-in area, service area, and car wash to the south end of the lot. Previously this area of the lot was only used for overflow vehicles. In addition to moving the check-in area, a second car wash was added (see Figure 4).

Finally, a fifth layout (Figure 5) was created in order to utilize the existing car wash. This layout left the check-in area at the south end, also adding some check-in along the east side. The service locations were placed just south of the existing car wash. This allowed the customers to be closer to the office while leaving enough check-in area for the busiest times.

4 ANALYSIS

All of these layouts were initially studied making the assumptions that the number of agents would not be a constraint. In order to accomplish this, a constant value was set for the number of agents working at an area. This number would not change, and, if set high enough, would prevent the manpower from being a constraint.

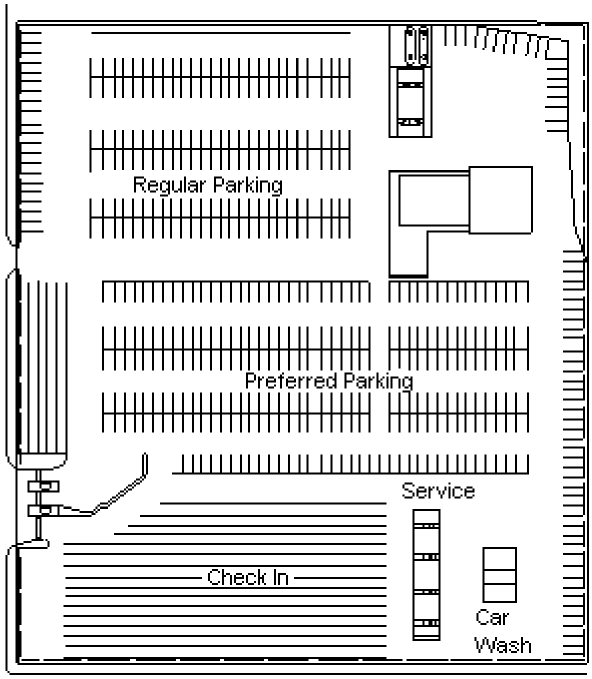


Figure 4: Fourth Optional Layout

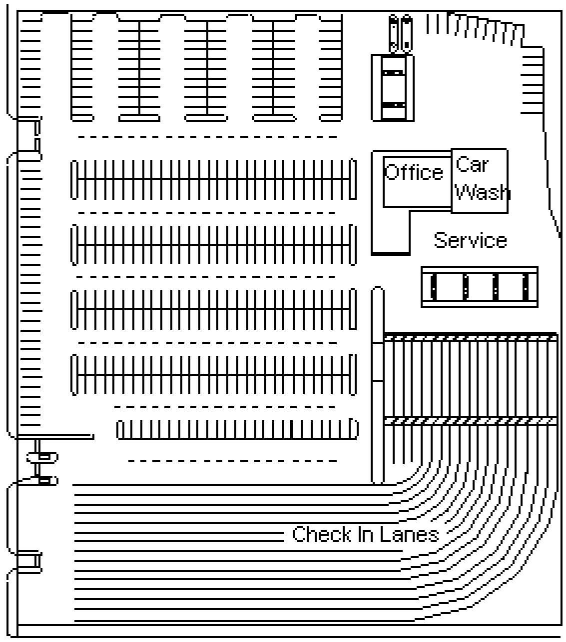


Figure 5: Fifth Additional Layout

Each model was then run at the current customer level. During each run, the average times spent processing, waiting in various areas, and travel times were tracked for both the cars and the customers. Special messages were created when certain overflow conditions arose, such as when the cars that were waiting for the car wash backed up into the service area. Each model was verified in this state to ensure that it was working correctly.

After the base model and the additional layouts were verified, the customer check-in and check-out level was slowly increased by factors of ten percent. As this number was increased, the number of vehicles passing through the check-in area was measured to determine at what point each layout would bottleneck and become less efficient. The point at which each layout bottlenecked was considered to be that layout's maximum capacity. In most cases, this bottleneck was caused by vehicles unable to park in the check-in area because this area was full. In the real world, these bottlenecks would be taken care of by adding additional manpower and double handling the vehicles. In the simulation, these occurrences would indicate the point at which the layout being studied would begin to be less efficient. The input level that each layout became bottlenecked would indicate how much growth that layout could manage.

In addition to measuring maximum capacity, some secondary measurements were also taken. These secondary considerations included the utilization of the agents, the customer wait and walking times, and the vehicle travel times. This was to ensure that increasing throughput did not overburden another critical aspect of the rental lot. These measurements were also measured at the given input level to measure performance against the current layout.

5 RESULTS

Due to the large check-in area, which eliminated the need for a separate overflow area, the fifth scheme would allow for a throughput increase of 40 percent over the current scheme. This was at least 10 percent better then the second best layout (layout 4), and at least 20 percent better then the other layouts.

Although the fifth layout excelled when throughput was measured, it didn't do so well in other categories. The larger check-in area for this layout created an additional burden on the rovers, which resulted in an increased rover utilization; 19.3-20.2 percent higher than the layout with the most efficient rover utilization based on a 95% confidence interval. The slotter utilization and the driving time between the car wash and the ready lines were also worse than the other proposed layouts. Even with these problems, a 40 percent increase in customer base was enough benefit to do some secondary analysis to optimize this layout.

6 SECONDARY ANALYSIS

After it was determined that the fifth layout allowed for the most growth, the secondary considerations were analyzed using various other options to fine tune the system. These parameters were the method by which the check-in lanes were filled, an additional car wash, and a manpower study. By looking at this layout in more detail and adjusting these parameters, it was hoped that the results could be improved upon.

In order to decrease the load on the rovers, the fifth layout was analyzed using all three check-in lane filling methods to see which was best. It was found that by filling the lanes evenly across all lanes, the customers were able to bring the cars closer to the service locations and the office. This meant that the rovers did not have to walk as far when pulling cars forward after checking in a customer. This also reduced the utilization of the rovers by 13 to 17 percent, which made it comparable to the other layouts.

The same system was also measured after adding a second car wash. This lead to a 10 percent improvement in slotter utilization, and a 30 second decrease in vehicle travel time between the service area and the ready lines. It was later determined that this would not have enough benefit to justify the modification.

The fifth layout was not better in every category. Customers had to walk 16 to 17 seconds longer when picking up cars, and slotters were utilized 3.8 to 5.4 percent higher when compared to the original layout. However, the additional capacity more than made up for these drawbacks.

7 SUMMARY

Although this simulation study did not show that one layout was better then the others in every category, it was able to quantify the differences, which made the final decision much easier. This also allowed for an immediate calculation of cost versus benefit, because it has been shown that by making the proposed modification to the lot and a few logistics changes, an immediate increase in customers of 40 percent or more was possible.

This simulation model was written in such a way that it is now possible to use this model as an aid in scheduling the agents. This is because of the method that was used to create it. This model was purposely built to be data-driven. This allows the simulation user to change the files that define the agent schedules, the desired number of ready vehicles, and even the customer check-in and check-out schedule. By changing this data, the customer can make decisions on how to schedule the employees, and how to best serve their customers.

AUTHOR BIOGRAPHY

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