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DETERMINING THE NUMBER OF MACHINE AT SEIZE CAR WASH AND DETAILING USING SIMULATING METHOD

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Abstract—*Seize car wash and detailing started its business in 2009. At that moment Seize starting a business car wash with 2 hydraulic washer unit. Beginning in 2011 the owner of the car wash and detailing Seize plans to increase the number of washing machine hydraulics by 3 units, bringing the total hydraulic washing machine there are 5 units. In April 2011, Seize car wash and detailing has begun to operate using 5 units of hydraulic washing machine simultaneously. After the addition of the washing machine, the queue consumers appear significantly reduced. Additional machines to minimize the queue, caused another problems instead. At certain days when the customers are few, the 5 machines are in standby to anticipate customers. While in fact at those certain days some of the machines are not operated at all. These idle machines actually adding costs for the company. On the other hand, when it's on peak even 5 machines are not enough. This is indicated by a long queue of customers on those days. These lead to the question of whether Seize's capacity too small? Or is it too large already? Operational time Seize car wash and detailing starts at 08:00 until 18:00, the total time is 10 hour operations. Based on the calculations (ideal condition), Seize is capable of serving up to 100 customers each day. The study for this case using queuing theory and will be done using simulation method with igrafx, which will analyze changes of the capacity to the amount of customers. The simulation showed that if the average customer interval is every 15 minutes, the required capacity is 3 machines on standby.*

Keywords: capacity, utility, queuing, simulation, car wash.

1. Introduction

Seize Car Wash and Detailing is a business that offers the consumer a car wash services and already operate quite a while, start when the year 2009. Its current condition is relatively good because every day there are definitely customers who come to wash the vehicle. Even sometimes also happens quite a long queue of customers who want to wash their vehicles. This was disclosed by the owner of Seize Car Wash and Detailing when asked about the number of consumers. Seeing that quite a lot of consumers who want to wash their vehicles and to provide better service to consumers by reducing consumer queues, Seize make additional investments in the form of addition of 3 units of lifting (hydraulic) which started operating in April 2011, bringing the total engine lift (hydraulic) owned by Seize car wash and detailing now consists of 5 units.

Here are the average data of consumers who come to wash their vehicles from the April to July 2011 where there has been the addition of 3 units of lifting (hydraulic), also included the least number of visitors and the most for any month. Data visitor numbers were obtained directly from the owner of Seize Car Wash and Detailing.

Table 1. Number of Seize's Customers

Month	Average number of Seize customer for 1 month	Minimum number of Seize customer for 1 day	Maximum number of Seize customer for 1 day
April	32 customers	14 customers	55 customers
Mei	35 customers	12 customers	58 customers
June	33 customers	15 customers	58 customers
July	41 customers	21 customers	66 customers

From the data on the number of consumers can be seen that the average consumer who comes every day pretty much, so with the addition of 3 units of lifting (hydraulic) is very helpful for consumers who want to reduce the queue to wash their vehicles even reduce the number of consumers who wash their vehicles canceled due to too long wait. In addition, with the addition of 3 units of lifting machines (hydraulic), Seize revenue also increased, due to an increase in capacity. Positive things that happen with the addition of 3 units of lifting (hydraulic) is also recognized by the owners Seize Car Wash and Detailing when doing interviews. The fact that happened on the field poorer addition of 3 units of lifting (hydraulic) does not solve the problem completely, because there is still a queue of customers especially in the days leading up to the weekend days (Friday to Sunday). The number of consumers who want to wash their vehicles on the day before the weekend and the weekend increased compared to other days. This is exacerbated by the arrival of irregular customers, in which customers come in quantities exceeding the capacity of the existing wash at the adjacent, so that automatically queues consumers can not be avoided.

Contrary to the time before the weekend, other problems also emerged on Monday through Thursday, with the addition of 3 units of lifting (hydraulic) were ineffective use of the machine. Host machine (hydraulic) 5 units remain in operation, but there was an idle machine or a machine that is not used to its full potential than any other machine for that day. Ineffective use of the machine that happens will have a direct impact on the cost of operations, where operating costs are not necessary to make the company profit is reduced and if it is left alone for long periods of time, certainly could endanger the company.

I. BUSINESS ISSUE EXPLORATION

A. Conceptual Framework

This conceptual framework works as a tool to sorts out anything that influences the issues. There are five main causes that influence the ineffective machine and customer queues, which is; unpredictable customer visits, facility capacity, bad assignment management, and no demand forecasting for future needs. The Conceptual Framework (see exhibit 1) begins at ineffective machine and customer queues. The ineffective machine usage lies in some of the car wash machine left on standby for quiet some time without really being used. The reason maybe the capacity is too large or maybe the relatively rareness of customer visits. In contrary to those conditions, on certain days when there's a sudden increase of customer visits, a queue occurs. Why queue? Maybe because the facility doesn't have enough capacity, or there's a sudden increase of customers visiting at a certain time at once.

According to Heizer and Render (2011), operational manager has to decide on capacity needs first, because it will have a direct effects on the company fixed cost. A facility that's too large will cause idleness, while too tiny will cause lost sales. Which is why it is important to decide on optimal capacity for the company to avoid unnecessary expenses. Jacobs, Chase and Aquilano (2009), states that there are 4 main causes of customers queuing; the distribution of customer arrivals (constant or not), pattern of customer arrivals (controllable or not), quantity of customer arrivals, patience of customers in queue. Customer queuing shows the quality of company's management system on anticipating customer arrivals.

Scheduling, Jacobs, Chase and Aquilano (Operations and Supply Management 12th edition) have 5 main objectives; punctuality, minimizing lead time, minimizing setup time or cost, minimizing work in process, and maximizing machine utility or human resources. Based on these, there are 2 important points that need to be managed well; machine utilization and work scheduling.

B. Analysis of Business Situation

Consumers who would like to wash vehicles each day varies, but in general the increase of consumers going from Friday to Sunday. Here are the data in the form of graphs that show the number of consumers for the past 4 months, starting from april 2011.

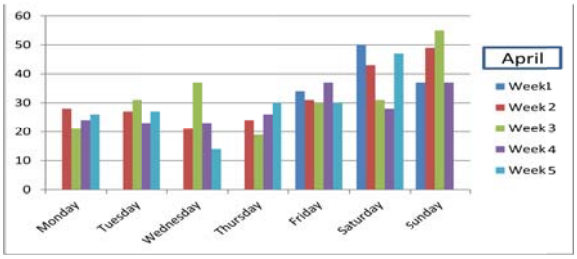

Figure 2a. Number of customers arrival in April

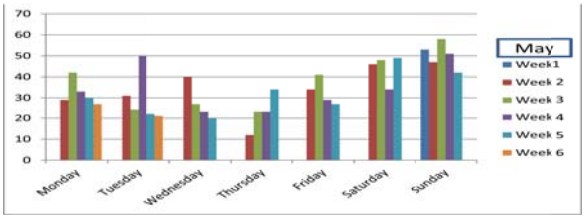

Figure 2b. Number of customers arrival in May

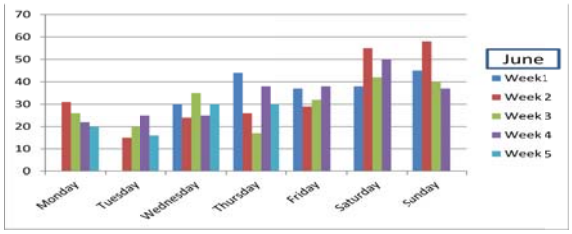

Figure 2c Number of customers arrival in June

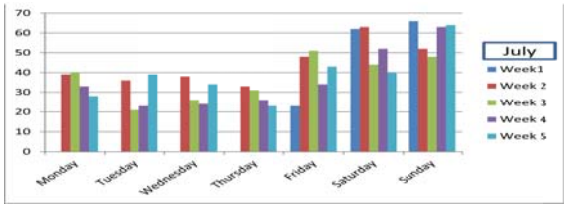

Figure 2d. Number of customers arrival in July

Based on data from figure 2, shows that an increasing number of consumers going on Friday, Saturday and Sunday. An increasing number of consumers that can occur up to 100% when compared to the other days (Monday to Thursday). Based on an interview with one of the staff who work in the Seize Seize and owners, in general Friday to Sunday is always a queue of consumers who are pretty much at certain times. These are observational data taken on Thursday to Wednesday, from 7 to July 13, 2011. The data and the length of the queue consumers in the

form of marked black colored box with white writing. The data also shows the use of machine tools that are used to clean vehicles consumers.

Table 2a. Customers queueing data on Friday 8th July 2011

1		2		3		4		5	
1	8:02	2	8:30	5	9:32	6	9:49	7	10:07
	9:02		9:22		10:29		10:48		10:58
3	9:26	4	9:29	10	10:24	16	11:48	17	11:48
	10:20		10:31		11:35		13:01		13:01
8	10:10	9	10:17	15	11:48	21	12:43	30	14:35
	11:02		11:10		12:51		13:56		15:40
11	10:48	12	11:11	20	12:36	25	13:38	33	15:18
	11:57		12:24		13:36		14:20	15	16:39
13	11:42	14	11:46	24	13:23	29	14:32	41	16:47
	12:44		12:46		14:40		16:02	17	18:00
19	12:25	18	12:20	27	14:10	35	15:41	46	17:29
	13:21		13:40		15:06		17:26	12	18:26
22	13:10	23	13:20	32	15:03	42	16:50		
	14:09		14:30		16:09	17	18:14		
26	14:01	28	14:28	37	15:49	48	17:43		
	15:04		15:46	5	17:04		18:29		
31	14:42	34	15:40	39	16:44				
8	16:05		17:22	28	17:33				
36	15:42	40	16:47	44	17:16				
	17:03	16	17:51	6	18:20				
38	16:24	45	17:19						
38	17:25	9	18:19						
43	17:05								
25	18:03								
47	17:37								
20	18:38								

Table 2b. Customers queueing data on Saturday 9th July 2011

1		2		3		4		5	
1	8:04	2	8:08	3	8:34	10	9:46	18	11:13
	8:59		9:10		9:23		10:39		12:22
4	8:35	5	8:37	9	9:45	17	11:00	24	11:57
	9:23		9:28		10:29		11:47	20	13:11
6	9:19	8	9:39	13	10:19	19	11:28	30	12:56
	9:53		10:32		11:17	14	12:15	11	13:57
7	9:38	11	10:11	16	10:58	23	11:48	35	13:39
	10:28		10:58		12:02	15	12:56		14:40
12	10:12	15	10:55	21	11:35	26	12:20	40	14:19
	11:02		12:09	17	12:57	42	13:48	26	15:11
14	10:53	22	11:39	27	12:27	32	13:20	44	14:44
	12:04	9	13:08	10	13:29	5	14:26	10	15:36
20	11:33	28	12:30	31	13:10	36	14:00	49	15:12
14	12:43	12	13:56	22	14:27	18	15:08		16:04
25	12:07	34	13:34	37	14:03	48	15:06	54	15:50
30	13:12		14:44	21	14:52		15:59		17:02
29	12:43	39	14:09	42	14:30	53	15:50	61	17:00
16	13:48	19	15:00	20	15:26		17:02		18:02
33	13:25	41	14:28	46	14:54	60	16:48		
9	14:22	13	15:23		15:42		18:00		
38	14:09	45	14:52	52	15:47				
22	14:57		15:48		17:01				
43	14:34	51	15:36	59	16:38				
4	15:30		16:31		17:42				
47	15:06	55	15:52						
	15:58		17:16						
50	15:34	58	16:32						
	16:28		17:39						
56	16:02	63	17:46						
	17:21		18:38						
57	16:22								
	17:28								
62	17:22								
	17:52								

Table 2c. Customers queueing data on Monday 10th July 2011

1		2		3		4		5	
1	8:06	2	8:11	3	8:09	4	8:17	5	9:30
	8:57		9:00		8:59		9:09		10:26
6	8:39	7	8:42	8	9:19	10	9:28	15	10:01
	9:49		9:59		10:08		10:26	10	11:00
9	9:25	11	9:32	12	9:46	14	10:00	20	10:39
6	10:11	4	10:31	12	10:46	2	10:59	8	11:39
13	9:51	16	10:06	17	10:24	19	10:31	25	11:13
8	10:55	7	11:04	11	11:36	9	11:31	7	12:11
18	10:30	21	10:40	23	11:04	24	11:07	31	11:50
12	11:35		11:30	6	12:02	3	12:08	8	13:03
22	11:00	26	11:14	28	11:40	29	11:41	47	15:52
7	11:56	4	12:10	8	12:30	2	12:47		17:01
27	11:30	30	11:49	35	12:49	36	13:08		
5	12:21	10	12:49		14:10		14:37		
32	12:00	33	12:30	39	14:32	41	14:40		
	12:57	13	13:41		15:39		15:59		
34	12:46	37	13:25	44	15:36	45	15:40		
	14:04		14:36		16:52		16:55		
38	14:02	40	14:36	50	16:45				
	15:11		15:47		17:50				
42	15:02	43	15:32						
	16:05		16:48						
46	15:40	49	16:20						
	16:47		17:24						
48	16:20	52	17:12						
	17:20		18:06						
51	17:01								
	18:00								

Based on the results of observations indicated by table 2, occurred on Friday 13 consumer queues that occur in the afternoon at 15:49, on Saturday, 24 consumer queues occur during the day starting at 11:33 on Sunday 22 consumer queues occur in the morning starting at 9:25. The data reflect the state according to its owners happens every week, the difference is dependent on the number of customers who come in for the day. For data on Monday through Thursday, can be seen from the data table 3, where the data shows the number of consumers who come to wash his car is not as much on Friday through Sunday. Queue consumer happens sometimes, but not cause an accumulation of consumers as on Friday through Sunday.

Table 3a. Customers queueing data on Thursday 7th July 2011

1		2		3		4		5	
1	8:21	2	8:30	5	9:38	10	10:49	17	13:07
	9:17		9:24		10:27		11:54		14:10
3	9:17	4	9:35	9	10:46	18	13:17	24	14:44
	10:03		10:21		11:46		14:32		16:14
6	9:59	8	10:34	12	11:30	28	15:22		
	10:39		11:33		12:30		16:42		
7	10:28	13	11:50	15	13:06				
	11:16		12:50		14:00				
11	11:02	19	13:24	23	14:21				
	11:44		14:28		15:22				
14	12:04	22	14:15	25	14:54				
	12:55		15:32		16:00				
16	13:07	27	15:08	32	17:36				
	13:58		16:41		18:37				
20	13:47	30	16:33						
	14:38		17:24						
21	14:13	31	17:25						
	15:39		18:15						
26	15:03								
	16:30								
29	16:25								
	17:21								
33	17:43								
	18:22								

Table3b. Customers queueing data on Monday 11th July 2011

1		2		3		4		5	
1	8:10	2	8:37	3	8:39	4	8:42	6	9:08
	9:11		9:31		9:49		10:11		10:17
5	8:47	7	9:10	11	10:25	12	10:33	26	13:56
	10:13	3	10:21		11:29		11:40		15:15
8	9:44	9	9:59	16	11:36	18	11:54	30	14:53
	10:59		11:05		12:42		14:13		16:07
10	10:25	14	11:02	21	12:37	23	13:50	35	15:37
	11:21		12:11		14:30	24	15:11		17:04
13	10:52	17	11:39	25	13:52	29	14:38		
	11:57		12:41	5	15:23	5	15:55		
15	11:25	20	12:31	31	14:59	36	15:42		
	12:46		14:15		15:50		17:01		
19	12:09	24	13:51	34	15:34				
	13:46	9	14:53		16:47				
22	13:26	28	14:33						
28	15:03		15:33						
27	14:16	33	15:26						
	15:46		16:31						
32	15:19	38	16:10						
	16:37		17:07						
37	16:06	40	17:32						
	16:58		18:15						
39	16:40								
	17:25								

Table 3c. Customers queueing data on Tuesday 12th July 2011

1		2		3		4		5	
1	8:50	2	9:19	6	10:51	8	11:14		
	9:49		10:26		12:27		12:34		
3	9:52	5	10:48	12	12:41				
	10:54		12:06		13:42				
4	10:38	9	11:37	15	14:00				
	11:23		12:36		15:12				
7	11:14	11	12:33	20	17:40				
	12:30		13:28		18:32				
10	12:13	14	13:52						
	13:15		14:52						
13	13:41	18	16:50						
	14:46		17:40						
16	15:38	21	17:55						
	16:28		18:59						
17	16:39								
	17:31								
19	17:00								
	17:44								

Table 3d. Customers queueing data on Wednesday 13th July2011

1		2		3		4		5	
1	8:25	3	9:00	4	9:11	16	12:34	8	11:03
	9:17		10:09		10:17	3	13:49		12:03
2	8:56	7	10:57	6	10:40	20	13:23	12	11:52
	9:59		11:52		11:41		14:29	35	12:58
5	10:34	10	11:34	11	11:35	24	15:11	17	12:46
	11:19		12:41		12:53		16:06	12	14:02
9	11:10	14	12:21	15	12:25				
	12:39		13:23		13:27				
13	12:18	18	13:02	19	13:08				
	13:47	29	14:27	22	14:20				
21	13:29	23	14:46	26	17:40				
	14:40		15:54		18:53				
22	17:01	25	16:03						
	18:09		16:46						

From the data shown by table 3, the queues that sometimes occurs on Monday through Thursday is not much, but the data also shows that the use of machine utilization is not optimal, it can be seen from the use of the machine, especially numbers 4 and 5, which are common idle condition compared to other machines. Idle condition makes the cost of operation of the company to the maximum, because there are facilities in your life but it is not used.

C. Problem Identification

Based on observations and conversations with the staff and the owner of the company, one of the problems that there are idle machines and consumer queue persists after washing capacity expansion Seize 3 units, bringing the total to 5 units. From exhibit 2, it appears that the ineffectiveness of the use of the machine is because the machine is in standby it all, but not accompanied by a number of customers who come in, causing the engine idle for a certain time. This condition if left idle for a long time will make a loss for the company.

Queue consumer happens by exhibit 2, this happens all the machines because they are alive and are being utilized all. This condition reflects as if Seize require greater capacity to meet consumer demand. Queue consumer's going to be bad for the company, namely the loss of customers who want to clean the vehicle, but who do not want to be patient to wait for another consumer queues were quite long.In this case, Seize Car Wash and Detailing new make new investments in April, according to the owner Seize Car Wash and Detailing will not invest further more for adding new machine, It necessary to maximize the existing facilities, but still be able to meet the demands of existing customers.The main challenge there is to analysis number of machine at Car Wash and Detailing.

3. Business Solution

D. Business Issues Solution

Based on the identification problem, there are two fundamental issues:

- Random customer arrival and not alleged.
- Utility use machines.

To resolve the problem, need review some point:

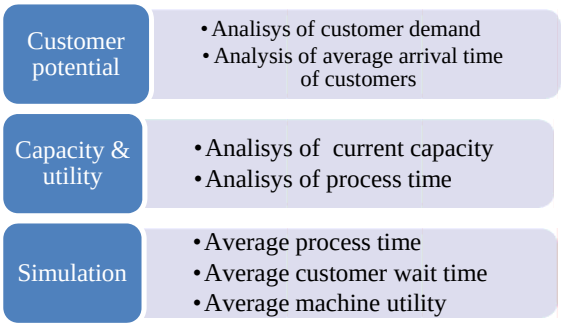

Figure 3. Business issue solution

E. Customer Potential

Based on field data observations made on 7 July 2011 to 13 July 2011, data showed the number of consumers who come for 1 week to wash the vehicle.

Table 4 .Customer arrival data for 7 day/ 1 hour

Working hour/ day	Time split each 1hour	Day 1	Day 2	Day 3	Day 4	Day 5	Day 6	Day 7
1	9:00	2	2	5	6	5	1	2
2	10:00	4	4	5	7	4	2	2
3	11:00	4	5	6	8	4	3	3
4	12:00	3	6	8	10	5	3	5
5	13:00	1	4	6	4	3	3	5
6	14:00	6	4	5	2	5	2	4
7	15:00	5	6	11	4	5	1	1
8	16:00	3	6	9	6	5	1	1
9	17:00	2	5	5	3	3	2	1
10	18:00	3	6	3	2	1	3	2
total of customers/ day		33	48	63	52	40	21	26

Based on these data, can be obtained by the average consumer arrival each day was 40.42, rounded to 40 customers everyday. Operational time Seize Car Wash and Detailing started at 08:00, until 18:00 hours. After the passing of the hours of 18:00, Seize Car Wash and Detailing not accept new customers who want to wash their vehicles, so that the working time effective operational Car Wash and Detailing Seize is 10 hours of work. Based on the above data can be obtained both the average arrival time of customers each day, by comparing the effectiveness of working time to the average number of customers per day. For the mathematical calculation, the average consumer arrival that will be used is 40, and the 10 hours of work time is comparable to 600 minutes, to obtain the results of a 15 min / consumer.

F. Capacity and utility

The capacity of the drying process has a value greater than the capacity of the washing process, so that the most likely consumer buildup occurred on the capacity of the washing process. The current maximum capacity for washing process is 5 concurrent activity and 7 concurrent activity for drying activity. The total capacity for the effective time of work is very dependent on the length of time the process of washing and drying. Based on the observations of Mr. Freddy, ideally washing and drying process can be completed within a maximum of 30 minutes per process per vehicle. Based on these data, the maximum capacity can be obtained for the washing and drying process, by dividing the effective working time to time the washing / drying, and then multiplied by the number of machines / slots available.

Table 5. Average process time

	average washing time	average drying time
day 1	26.33333333	28.08333333
day 2	36.07692308	26.92307692
day 3	29.11764706	26.76470588
day 4	33.07142857	28.07142857
day 5	40.41666667	32.91666667
day 6	29.11111111	28.33333333
day 7	43.42857143	24.71428571
average	33.93652589	27.97240435
standard deviation	6.347382722	2.509085866

Based on observational data, the average processing time is obtained by washing the 34 (33.93) minutes and the average drying time that happened was 28 (27.97) minutes, so that the maximum capacity is based on observational data: Washing capacity is: 600 minutes / 34 minutes x 5 machines. Ideal capacity maximum values obtained for 10 work hours is 88 (88.23) for vehicle washing process. While the drying capacity is: 600 minutes / 28 minutes x 7 slot. Ideal capacity maximum values obtained for 10 work hours is 150 vehicles for the drying process.

G. Simulation

Simulations were performed using the iGrafx program with the parameters used already searched in section B (potential consumers) and C (capacity and utilities):

- Time interval arrival of customers: 15 minutes
- Average time for washing process: 34 minutes
- Average time for drying process: 28 minutes

Diagram programs created are as follows

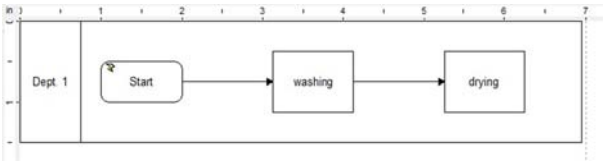

Figure 4. Process structure by iGrafx

The simulation process is also done by changing the number of washing machines that use of the only open 2 engine units only up to 5 units. It aims to compare the utility machine to consumer queues that occur.

Table 6. simulation result with interval arrival for 15minute

	2 machine	3 machine	4 machine	5 machine
Start (unit(s))	35	35	35	35
Washing (unit(s))	32	34	34	34
Drying (unit(s))	30	33	33	33
avg cycle washing (minute)	74.26	37.53	34.08	32.62
avg cycle drying (minute)	28.18	28.06	28.06	28.06

avg work washing (minute)	32.81	32.39	32.39	32.39
avg work drying (minute)	28.18	28.06	28.06	28.06
avg wait washing (minute)	41.45	5.14	1.69	0.24
avg wait drying (minute)	0	0	0	0
number of finish transaction in 10 work hour	30	33	33	33
avg cycle for finish in 10 work hour (minute)	100.2	65.83	62.28	60.78
avg work for finish in 10 work hour (minute)	61.2	60.54	60.54	60.54
avg wait for finish in 10 work hour (minute)	39	5.29	1.74	0.24
Time-Weighted Average Resource Utilization washing (%)	90.9	62.17	46.63	37.3
Time-Weighted Average Resource Utilization drying (%)	21.1	22.34	22.34	22.34
Total queue (unit(s))	30	13	6	1

Simulation subsequent consumer arrival time compare if longer, which is every 30 minutes, with the washing and drying process parameters remain the same.

Table 7 simulation result with interval arrival for 30minute

	2 machine	3 machine	4 machine	5 machine
Start (unit(s))	20	20	20	20
Washing (unit(s))	17	18	19	20
Drying (unit(s))	15	15	15	15
avg cycle washing (minute)	36.66	33.15	32.54	31.85
avg cycle drying (minute)	28.16	28.16	28.16	28.16
avg work washing (minute)	32.8	32.81	32.54	31.85
avg work drying (minute)	28.16	28.16	28.16	28.16
avg wait washing (minute)	3.87	0.34	0	0
avg wait drying (minute)	0	0	0	0
number of finish transaction in 10 work hour	15	15	15	15
avg cycle for finish in 10 work hour (minute)	64.35	60.38	60.38	60.38
avg work for finish in 10 work hour (minute)	60.38	60.38	60.38	60.38
avg wait for finish in 10 work hour (minute)	3.97	0	0	0
Time-Weighted Average Resource Utilization washing (%)	48.44	34.48	26.41	21.23
Time-Weighted Average Resource Utilization drying (%)	10.62	10.92	11.27	11.38
total queue (unit(s))	8	3	1	0

Next simulation compares if consumers faster arrival time, which is every 10 minutes, with the washing and drying process parameters remain the same.

Table 8. simulation result with interval arrival for 10minute

	2 machine	3 machine	4 machine	5 machine
Start (unit(s))	60	60	60	60
Washing (unit(s))	35	50	54	55
Drying (unit(s))	33	47	51	52
avg cycle washing (minute)	132.6	57.59	38.08	33.81
avg cycle drying (minute)	28.2	28.08	28.02	27.95
avg work washing (minute)	32.4	32.39	32.93	32.87
avg work drying (minute)	28.2	28.08	28.02	27.95
avg wait washing (minute)	100.8	25.02	5.15	0.94
avg wait drying (minute)	0	0	0	0
number of finish transaction in 10 work hour	33	47	51	52
avg cycle for finish in 10 work hour (minute)	156.6	83.84	65.55	61.44
avg work for finish in 10 work hour (minute)	60.6	60.66	60.45	60.45
avg wait for finish in 10 work hour (minute)	96	23.19	5.11	0.99
Time-Weighted Average Resource Utilization washing (%)	96.35	93.09	77.29	63.05
Time-Weighted Average Resource Utilization drying (%)	22.65	32.77	35.02	35.49
total queue (unit(s))	55	52	33	9

Base on simulation by increasing number of machines, proving weighted average resource utilization for washing will be smallerand increasing Weighted average resource utilization for drying. More number of machine open, wait time for washing will be smaller and queue will reduce.

4. Conclusion and Implementation Plan

By looking at the above simulation results, it should Seize Car Wash and Detailing can operate normally on Monday through Thursday, with only three units of course, assuming the average customer arrival time is every 15 minutes, if the ideal maximum total consumers who may is 40 consumer every day. Crowded conditions on Friday to Sunday also should be overcome simply by using 4 pieces of machinery, but it will happen buildup consumers for some time because the utility engine high enough when only using 4 pieces of machinery.

The above can be applied normal to ignore the factor of technical errors that may occur during the field and the human error factor, where the human operator assigned here is the process of washing and drying the vehicle. In the simulation above, the condition is always assumed to be the operator quickly and precisely, so that during the process of washing and drying the vehicle does not happen too much time deviations.

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Exhibit 1 Conceptual framework

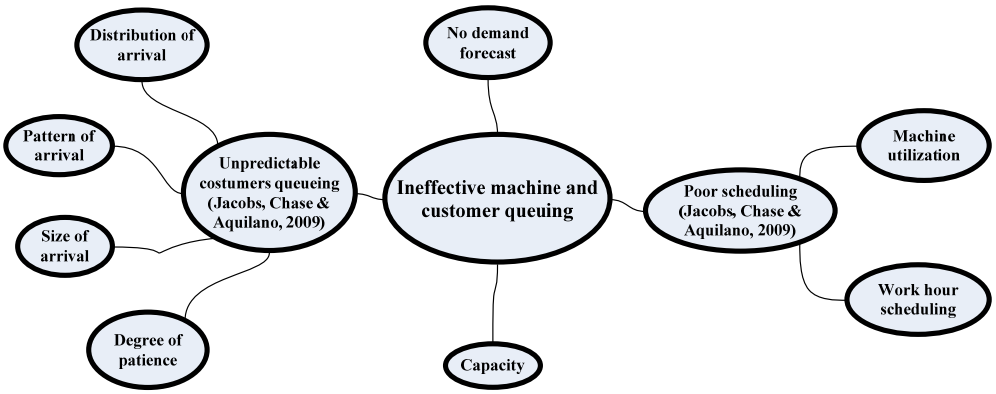

Exhibit 2 Current Reality Tree (CRT)