Effectiveness of the Number Coding Scheme for the Improvement of Parking Conditions in Saint Louis University (SLU) Main Campus

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Abstract: The problem of employee parking in SLU-Main campus received a considerable attention with the increasing number of employees acquiring parking privileges. Consequently, it is essential that the parking supply meets the increasing demand. Hence, the study was conducted for the purpose of determining the effectiveness of Number Coding scheme for the improvement of parking availability in SLU Main Campus. Survey on parking usage and traffic counts of inflow and outflow of vehicles were performed as part of data gathering. Parking probability and statistics were computed to evaluate the state of parking in the campus. Results show that only 25 percent of the total vehicles using the parking facilities have car pass. Mondays have the highest parking usage. At any time, one can find at least one parking stall which an employee can utilize. The parking supply meets the parking demand. Thus, the enforcement of the number coding scheme is effective.

***Keywords*:** Parking, Probability, Queuing, Number Coding Scheme

1. INTRODUCTION

This section discusses traffic congestion problems in the Central Business District (CBD) in Baguio City, Philippines in which the City Government adopted the "Number Coding" scheme to partly alleviate traffic congestion especially in the CBD. There were loopholes in the implementation of the number coding scheme that eventually increased the number of car ownership. The scheme also encouraged employees to park their cars before 7 AM in their workplace since the scheme takes in effect from 7 AM to 7 PM. Thus, there were parking insufficiencies in the establishment concerned. The implementation of Number Coding Scheme as a solution to avoid parking insufficiencies is so far the best solution especially with a limited Floor Area Ratio (FAR) as for the case of SLU main campus. With a limited FAR, even the construction of a multi-level parking is not possible.

1.1 Baguio City

Urban congestion is one factor that affects the parking system in Baguio City. The City remains on the list of must-see places for tourists, both local and foreign and it also stands as the education center in North of Luzon. Because of these reasons, population both local and foreign continuously increases. As population increases, traffic congestion worsened especially in the Central Business District (CBD).

More than 32,000 vehicles excluding tourists' vehicles were registered by the end of 2009 *(RLTO, 2009)*. With this number of vehicles, taking into consideration its continuous increase, urban traffic congestion is expected to intensify. Greater movement of people either through the use of private or public utility vehicles needs to be satisfied as population increases. To accommodate all the movement of people, it is not only the local government officials of Baguio City who are going to act but also establishments, educational institutions,

malls, and other private entity owners because their success and failure, and the safety of people can be linked to an efficient management of traffic and parking systems.
The local government of Baguio City adopted the Number Coding Scheme through Administrative Order No. 503 as experimental project for all private and public vehicles to help alleviate traffic congestion and improve economic growth since traffic congestion can hamper productivity in both public and private sectors. During the implementation, on-street parking along roads, streets, and thoroughfares within the central business district and its immediate environs shall be prohibited from 7 am to 7 pm daily, Monday thru Friday *(Baguio City Administrative Order No. 503, s. 2002).* The Number Coding Scheme's implementation is that vehicles with plate number ending in "1" and "2" as an example are not allowed to travel within the Central Business District on a Monday from 7 AM to 7 PM and so on as shown in Table 1.

Table 1. Vehicle prohibition in CBD on each day of the week

Day of the week	Plate Numbers with Last Digit
Monday	1 & 2
Tuesday	3 & 4
Wednesday	5& 6
Thursday	7 & 8
Friday	9 & 0

1.2 Saint Louis University-Main Campus

A common problem at university campuses today centers on the issue of parking space shortages. Parking space is either insufficient for driver's demand, poorly allocated or both. This leads to insufficient campus parking capacity.
In Saint Louis University (SLU), the annual increase of student enrollment leads to continuous hiring of employees. These employees owning private vehicles eventually increased the demand of parking spaces inside the main campus. One of the reasons of this insufficient parking availability is the implementation of the Number Coding Scheme in the CBD of Baguio City. Employees affected by the scheme park their private vehicles before 7 AM inside the campus. Thus, vehicles parked from 7 AM to 7 PM to avoid the city wide number coding scheme in turn diminished available parking spaces for employees especially faculty members starting their teaching classes from 8:30 AM onwards. To discourage such practice, the SLU administration as recommended by a previous study entitled "An Evaluation of the Current Parking System of Saint Louis University (SLU) - Main Campus" implemented its own Number Coding scheme inside the campus disallowing vehicles to park inside the main campus at any time of the day except 5 pm onwards as reference to Table 1. Suspension of the Number Coding scheme in the CBD during holidays does not affect the SLU administration's own number coding scheme inside the campus.

A study was made by Omengan et. al (2011) entitled "An Evaluation of the Current Parking System of Saint Louis University (SLU) - Main Campus." The parking demand reached to a maximum of 158 cars during the data gathering session exceeding the constant parking supply of 142 spaces. The parking demand was most of the time above the 142 spaces supplied by the university and remained above the limit throughout the day.
The parking duration of vehicles extended to an average of 4.7 hours. This value may be brought out by the fact that most of the owners of the parked vehicles are regular employees working 8 hours a day. Data gathered yields a low turnover rate of 1.41 vehicles per space which indicates that most of the parking stalls are utilized by an average of only 1 or 2 cars

throughout the day (8 hours). This also indicates that one car makes use of one space for a long period of time. Their study also showed a parking volume of 26.08 veh/hr.

1.3 Framework of the Study

SLU Main Campus, being the parking study area, is where the researchers gather the necessary data needed in the study as shown in Figure 1. Parking spaces are designated in red boxes. The phases of the study are represented by the framework shown in Figure 2. The focal point of the research is to ascertain the effectiveness of the number coding scheme that was implemented. To be able to verify its effectiveness, the sufficiency of the parking area should first be determined through parking capacity calculations. Inadequacy of parking leads to further identification of probable solutions which may either be geometric or enforcement. The solutions must then be evaluated based from its efficiency. Thus, the most efficient solution can be drawn.

Figure 1. Parking plan designations in SLU Main Campus

Geometric solutions such as adding more parking space is not recommended for this study due to limited space. Also, the construction of a multi-level parking space is expensive and no space is available for it because of the limited Floor Area Ratio. Other enforcement solutions such as parking fee as an economic solution will probably be studied further in case the number coding scheme will not be effective.

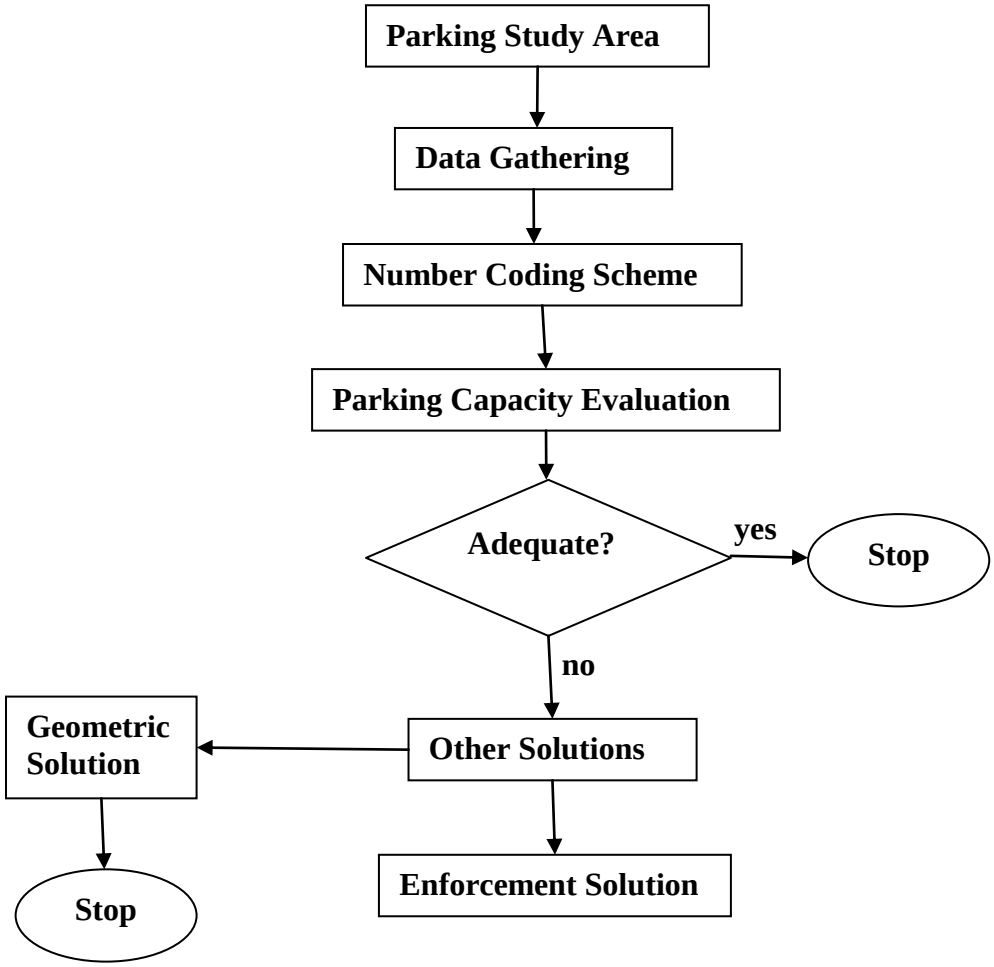

Figure 2. Framework of the Study

1.4 Number Coding Scheme

Number Coding Scheme is a vehicular volume reduction program which regulates the operation of certain vehicles on certain areas. It uses the last digit of the plate number to distinguish if the vehicles are allowed to enter specific areas on a certain day.

1.4.1 Number Coding Scheme in SLU as per Registered Vehicles

SLU has implemented its own number coding scheme on all its campuses except at the SLU Hospital last July 2011. The principle is similar with Baguio City's number coding scheme. It regulates the entrance of vehicles under coding from entering the campus at any time of the day. The scheme is effective even if there is a suspension of coding within the city.

In Figure 3, it can be seen that the bulk of vehicles are those with plate numbers ending in 3-4 and 7-8 having a percentage of 21.18 percent and 23.15 percent, respectively. Those vehicles contribute greatly to the parking demand especially during Mondays, Wednesdays and

Fridays. Consequently, Monday, Wednesday and Friday are the peak days for the reason that these days have high parking demand.

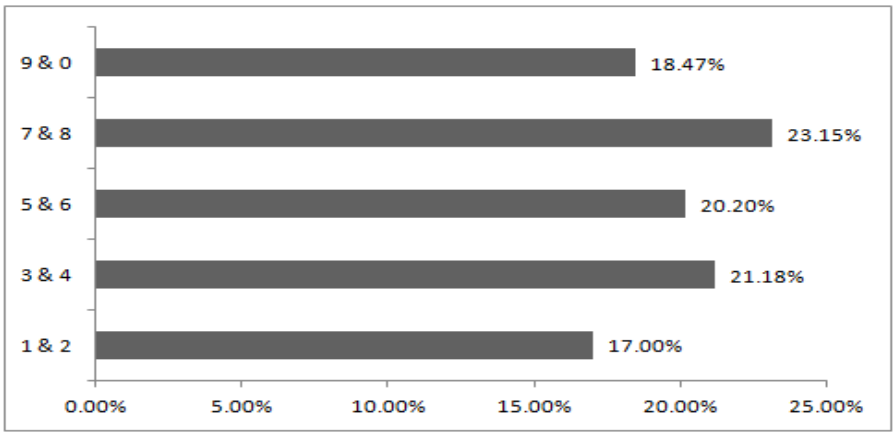

Figure 3. Classification of SLU registered vehicles by number code

In Figure 4, it is observed that 4.49 percent of the total vehicles which utilized the parking facilities were regulated by the number coding scheme. The vehicles that are not prohibited by the scheme should be the priority on using the stalls in order to satisfy the demand. The graph shows that vehicles under 3-4 and 7-8 number codes have the highest percentage of vehicles parked with 29.78 percent and 24.16 percent, respectively. This shows that vehicles having plate numbers ending with 3 or 4 have huge impact in the parking demand on Mondays, Wednesdays, Thursdays and Fridays.

1.4.2 Number Coding Scheme in SLU as Surveyed

a.) Day 1: January 6, 2012 (Friday)

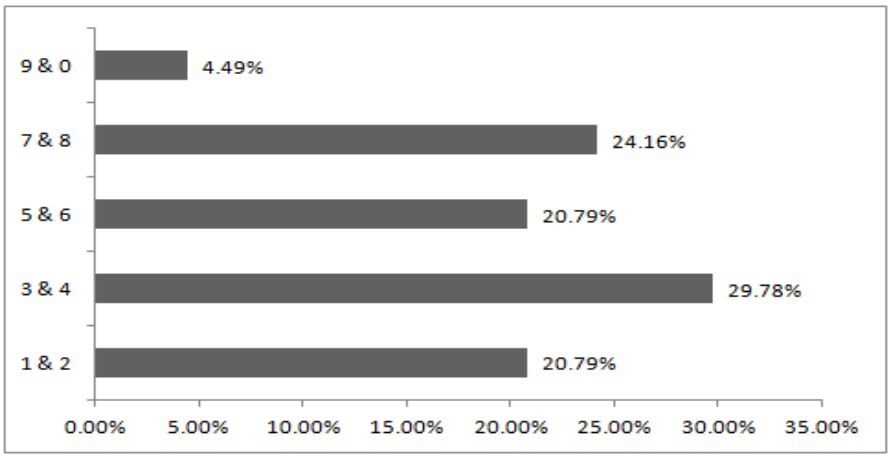

Figure 4. Classification of parked vehicles by number code on January 6, 2012

b.) Day 2: January 9, 2012 (Monday)

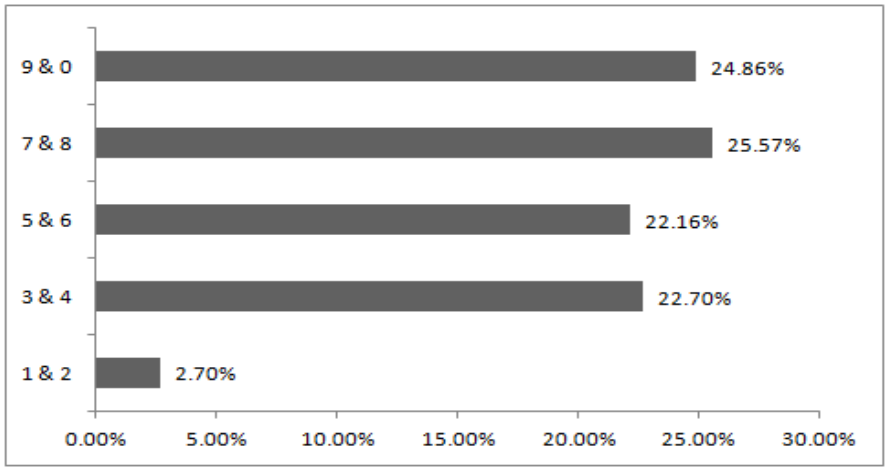

Figure 5. Classification of parked vehicles by number code on January 9, 2012

In Figure 5, it is shown that 2.7 percent of the total vehicles were able to utilize the parking facilities despite that those vehicles were restricted by the number coding scheme. The figure indicates 7-8 and 9-0 number codes have the highest percentage of vehicles parked with 27.57 percent and 24.86 percent, respectively.
It can be drawn that most of the volume of vehicles comes from vehicles with number code 7-8. Those vehicles contribute greatly to the parking demand during Mondays, Tuesdays, Wednesdays and Fridays.

2. METHODOLOGY

The research was based on the information about the capacity and use of the existing parking facilities. The study involved a survey on the parking usage and traffic counts on the inflow and outflow of vehicles in the university grounds. A preliminary investigation includes interviews and ocular inspection to determine the days with large parking volume in which the days of data collection were based. Parking statistics and probability were computed based on the surveyed data. The study used the M/M/N Queuing Theory to compute for the parking probability. A comparison of a previous study and this study on parking conditions in the area is shown in this section.

2.1 Research Design and Methodology

The study is developmental in principle. Hence, a systematic work is drawn on knowledge gained from a previous research and current trends to improve the present conditions. This research is based on the information about the capacity and use of the existing parking facilities. It involves a survey on the parking usage and traffic counts on the inflow and outflow of vehicles in the university ground. A preliminary investigation includes interviews and ocular inspection to determine the days with large parking volume in which the days of data collection are based. Parking statistics and probability are computed based on the

surveyed data. The study also includes a comparison of previous and present parking conditions in the area. From these, the number coding scheme's effectiveness is evaluated.

2.2 Duration and Locale of the Study

The research limits the study within the vicinity of Saint Louis University Main Campus, Baguio City. The area under study is divided into several zones. Parking Study Area "A" includes parking stalls located between Otto Hahn Building and Hospital of the Sacred Heart Buildings while Parking Study Area "B" encompasses parking stalls situated along parts of Otto Hahn Building and Rizal Buildings. Parking spaces between Diego Silang Building and Centennial Park belong to Parking Study Area "C" while parking spaces between Diego Silang and Burgos Buildings are under Parking Study Area "D." Parking Study Areas" E" and "F" consists of parking areas at Gate 3 and Gate 4, respectively. Parking Study Area" G" considers the parking stalls in front of the Guidance Center (refer to Figure 1 for the illustrations of the Parking Study Areas). Supplemental data includes technical information from Student Affairs Office data, Registrar's Office data, and a previous study by Omengan et al. (2011) entitled "An Evaluation of the Current Parking System of Saint Louis University (SLU) - Main Campus."

2.3 Data Gathering Procedures

The following procedures are based from a manual entitled "Introduction to Traffic Engineering a Manual for Data Collection and Analysis" by Thomas R. Currin. The study area should be no larger than one observer can handle. The nature and size of the retail lot should allow the observer to see the license plate of each vehicle and permit easy passage from one space to another. Data collection forms are shown in Figure 6.

2.3.1 Sketch the lot, and determine the best path for data collection.

Data collection requires the observer to circulate through the lot of a regular interval, follow a predefined path, and record the license plate number of the vehicles occupying the spaces. To best accomplish this task, various routes through the lot should be examined and the best one is selected. It is important that the observer follows this same route each and every time data is collected. Varying from the predetermined route will jeopardize the credibility of the data. Since parking space numbering is rare, a sketch of designated route through the lot is kept with the data collection sheets so that the numbered data entries can be associated with the spaces.

Parking Study

Data Collection Form

Location: _____ Observer/s: _____

Date: _____ Time: _____ Weather: _____ Sheet _____ of _____

	Vehicles Parked			
Space	+ 15	+30	+45	+60
1				
2				
3				
4				
5				
6				
7				
8				

(a)

Parking Study

Data Collection Form

Location: _____Observer/s:

_____

Date: _____Time: _____Weather: _____Sheet _____ of

_____

Time	Vehicles	
	Plate No.	Total No.
7:00-7:15		
7:16-7:30		
7:31-7:45		
7:46-8:00		
8:01-8:15		
8:16-8:30		
8:31-8:45		
8:46-9:00		
9:01-9:15		
9:16-9:30		

(b)

Figure 6. Data collection forms for parking survey

a. Prepare data collection sheets.
   The data collection form shown in Figure 3b includes one row for each parking space and one column for each 15-minute interval.
b. Collect the data.
   At least 11 hours of data will be collected at 15-minute intervals. This collection period is chosen so that there will be sufficient data to have a more comprehensive evaluation of the parking activity. At the start of each period, the observer proceeds through the lot, following the prescribed route and recording the license plate number of each parked vehicle. Empty spaces may be left blank. On completing one circuit, the observer will wait until the quarter hour is reached and proceed with the next round of data collection. This is repeated until the full study time expires.
c. Check the data before leaving the field.
   As always, data should be reviewed prior to leaving the field and any discrepancies resolved.

2.3.2 Parking Statistics (Inflow and Outflow of Vehicles)

a. Identify the study area.
   The study area is the entrance and exit of the campus.
b. Prepare data collection sheets.
   The data collection form includes one column for each 15-minute interval for the whole time of observation, one column for the plate number of vehicles entering or exiting and

one column for the total number of vehicles entering and exiting for every 15-minute intervals.

c. Collect the data.
   At least 11 hours of data will be collected at 15-minute intervals. One observer will be assigned at the entrance and one at the exit. The observers will list the plate number of vehicles arriving or departing every 15-minute intervals throughout the time of observation.
d. Check the data before leaving the field.
   As always, data should be reviewed prior to leaving the field and any discrepancies resolved.

2.4 Treatment of Data

The following procedures on the treatment of data on parking usage are also based from a manual entitled "Introduction to Traffic Engineering a Manual for Data Collection and Analysis" by Thomas R. Currin.

2.4.1 Parking Usage

a. Summarize the data.
   The investigator should summarize the number of vehicles that used the space during the observation period as well as the total time each space was occupied.
b. Compute parking statistics.
   Several descriptive values can be found from the data collected, all of which will provide insight as to the behavior of the users of the lot and aid in the identification of deficiencies. These are parking volume, turnover, duration, load, and accumulation. The formulas used are as follows:

$$\text{Parking Volume} = \frac{\text{Total Vehicle Parked}}{\text{Observation Period}} \tag{1}$$

$$\text{Turnover Rate} = \frac{\text{Total Vehicle Observed}}{\text{Total Parking Spaces}} \tag{2}$$

$$\text{Parking Duration} = \frac{\text{Total Vehicle-Hours}}{\text{Total Vehicles}} \tag{3}$$

$$\text{Parking Load} = \frac{\text{Total Vehicle-Hours}}{\text{Total Space-Hours}} \tag{4}$$

Whereas the parking load allows an examination of the use of available parking from one perspective, a computed value that may better represent utilization of the parking is *parking accumulation.* The accumulation is simply the total number of vehicles using spaces at a particular time. Plotting this accumulation over time shows graphically how the parking load changes as time passes and is useful in identifying high-demand periods.

2.4.2 Parking Probability

Using the data gathered in the parking usage and the inflow and outflow of vehicles, the parking probability, which is the probability that the driver of a vehicle may find a parking space at the time of its arrival, can be computed using the formulas shown below.

Queuing theory is one method of computing the parking probability. The M/M/N Queuing is the most appropriate method among other queuing methods because of the non-uniform arrival and departure of vehicles and a varying number of parking spaces available.

The available number of parking spaces for every 15-minute intervals can be taken from the data on the parking usage. The arrival and departure of vehicles for every 15-minute intervals can be taken from the inflow and outflow of vehicles.

Let λ - arrival rate, μ - departure rate and N – number of available parking stalls. Then $\rho = \frac{\lambda}{\mu}$ is the traffic density or utilization factor.

M/M/N Queuing:

$$P_o = \frac{1}{\sum_{n=0}^{N-1}\frac{\rho^n}{n!} + \frac{\rho^N}{N!(1-\frac{\rho}{N})}} \quad (5)$$

$$P_{n>N} = \frac{P_o\ (\rho^{N+1})}{N!N\ (1-\frac{\rho}{N})} \quad (6)$$

$$P = 1 - P_{n>N} \quad (7)$$

where

P_o is the probability of having no vehicles parked in the study area,
$P_{n>N}$ is the probability of not finding an available parking stall, and
P is the probability of finding an available parking stall.

3. DATA AND RESULTS

Data presented in this section will compare a previous study from 2011 and this study to know the changes of parking availability with the implementation of the number coding scheme.

3.1 Number of Parking Stalls

The number of parking stalls was gathered by manual counting in which the researchers were guided by the security personnel. The total number of parking stalls in the whole parking area of Saint Louis University is presented in Table 2.

Table 2. Designation of Parking Stalls

Total Reserved Parking Stalls (Administration, Deans and SLU Vehicles)	:	35
Parking Stalls for Employees	:	109
Total Parking Stalls (Reserved and Employee Parking)	:	144

3.2 Registered Vehicles vs. Unregistered Vehicles

This section presents the number of registered vehicles and the unregistered vehicles that were able to enter the campus. Data was based on the registered vehicles at the Student Affairs Office in SLU as of January 2012.

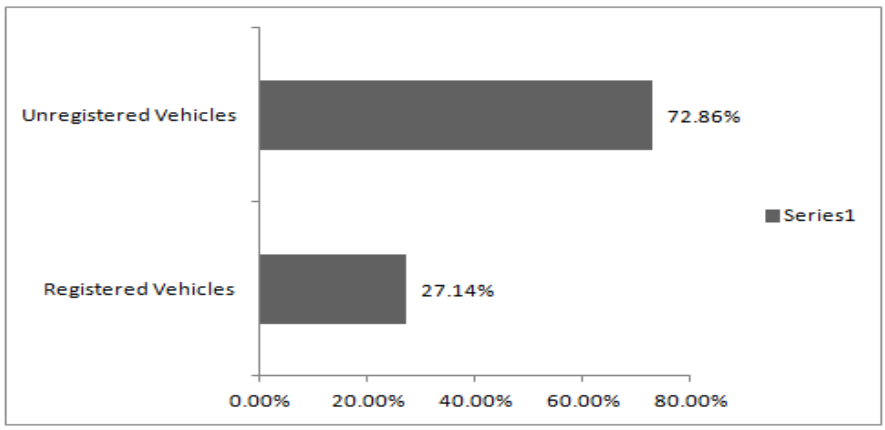

Figure 7. Percentage of registered and unregistered vehicles for Jan. 9, 2012 (Monday)

Figure 7 shows 27.14 percent of vehicles having a car pass while 72.86 percent of vehicles have no car pass. These points out that only a small portion of vehicles serviced by the parking area are registered. The unregistered vehicles are allowed to park in the campus while processing their car pass application.

3.3 Parking demand vs. supply

Figure 8 shows parking demand and parking supply taken from a previous study by Omengan et. al (2011) entitled "An Evaluation of the Current Parking System of Saint Louis University - Main Campus." Parking demand exceeded the 142 stall parking supply. Parking demand taken into account was the surveyed total number of vehicles parked every 15 minutes and also the rejected number of vehicles that were not allowed to enter the campus. It can be observed that there is insufficiency of parking supply. The number of vehicles parked every 15-minute intervals and the surveyed number of parking stalls were the basis of the graph on the parking demand versus parking supply.

The data on January 9, 2012 (Monday) as shown in Figure 9 was the only day taken into account for the purpose of comparing the present parking demand and supply with the previous study. In this study, the parking supply having 144 parking stalls is constant. The parking demand is the surveyed total number of vehicles parked every 15 minutes in the parking study area from 6:30 am to 6 pm. As shown in the figure, the parking demand is below the parking supply. The parking demand peaked at 127 vehicles. With 144 parking supply, the least number of available parking spaces is 17 stalls but these include both parking for employees and reserved parking for the administration. There is an improvement of parking supply with the implementation of the number coding scheme as compared from the previous study.

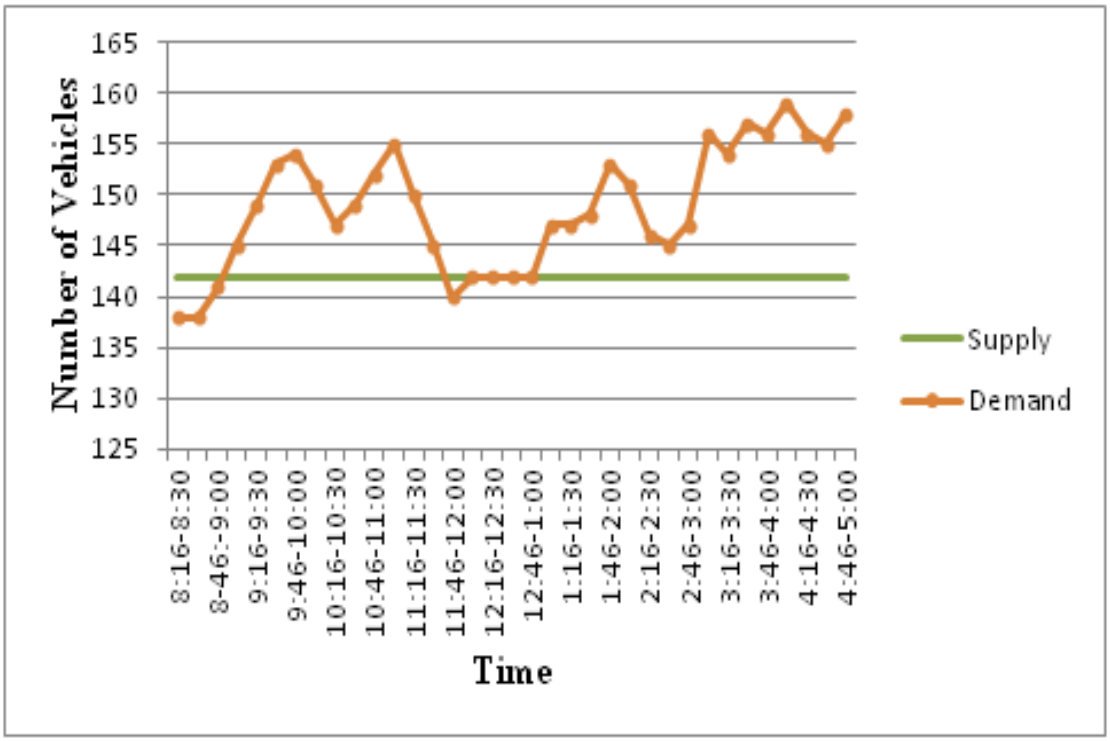

Figure 8. Parking demand vs. parking supply (one day data taken for school year 2011)

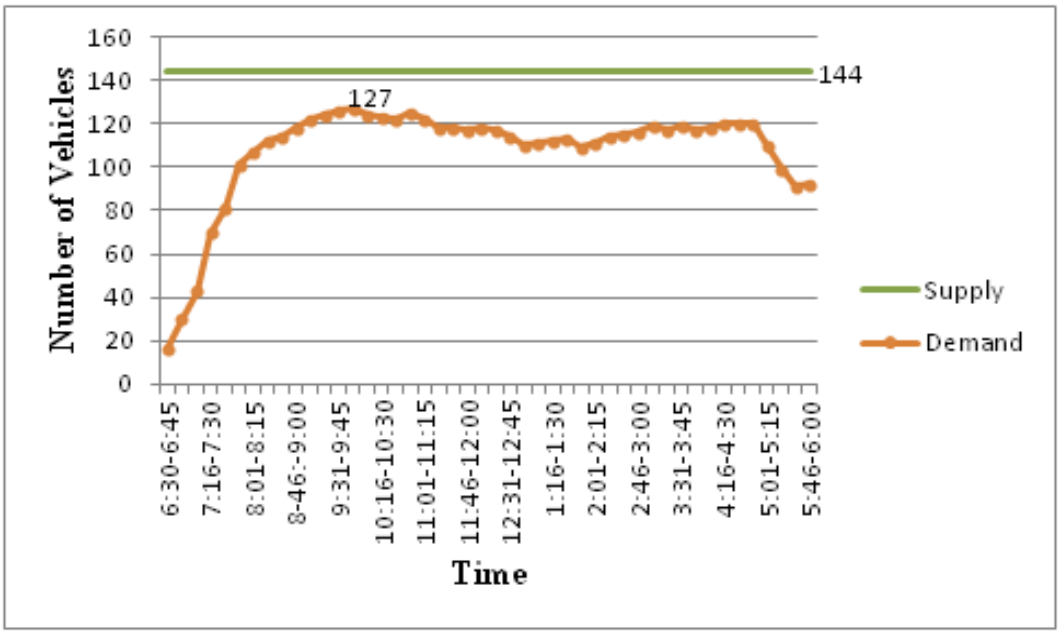

Figure 9. Parking demand vs. parking supply with number coding scheme (one day data taken for school year 2012)

3.4 Data comparison between 2011 and 2012 study

This presents the average values of the parking volume, turnover rate, duration, parking load and parking accumulation for January 7, 2012 and January 9, 2012.

Table 3. Average parking statistics for 2012 data with number coding scheme

Parking Statistics	:	January 7	:	January 9	:	Average
Parking Volume (veh/hour)	:	21.91	:	21.22	:	21.57
Turnover Rate (veh/space)	:	1.67	:	1.69	:	1.68
Duration (hour/veh)	:	4.53	:	5.08	:	4.81
Parking Load (%)	:	65.97	:	74.91	:	70.44

Parking volume is the hourly representation of the number of vehicles using the facility. As shown in Table 3, Day 1 has a parking volume of 21.92 vehicles per hour which means that 241 vehicles used the parking facility during the whole time of observation while Day 2 has a volume of 21.22 vehicles per hour with 244 vehicles. On the average, the parking volume is 21.57 vehicles per hour which means that there were 243 vehicles serviced.

Parking load is the amount of space used. The mean parking load is 70.44 percent indicating that more than a quarter of the parking facility was free most of the time.

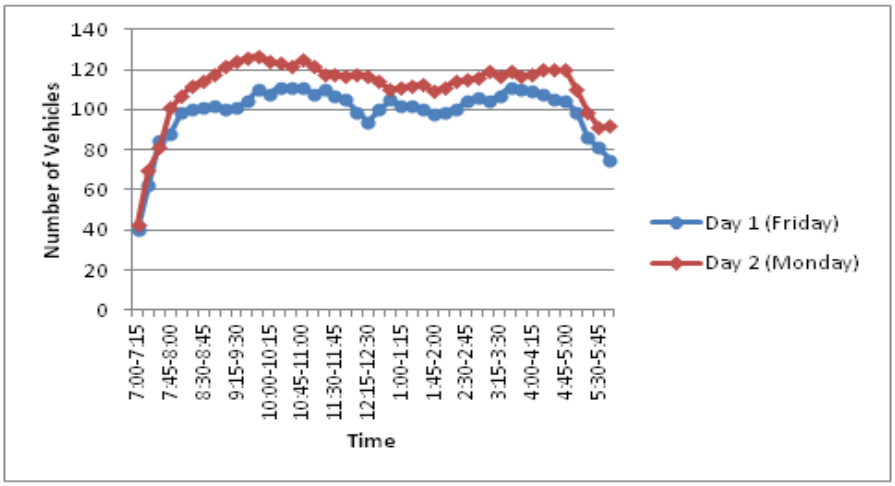

Figure 10. Parking accumulation of days of observation

Based from Figure 10, it can be observed that Day 2 (Monday) has a higher parking demand as compared to Day 1 (Friday) making Monday as the peak day.

Table 4 presents a comparison between the previous study in school year 2011 as aforementioned without the number coding scheme and parking conditions with the number coding scheme for school year 2012.

Table 4. Parking analysis results from 2011 data and 2012 data

Parking Statistics	:	Data for 2011	:	Data for2012 With Number Coding Scheme
Parking Volume (veh/hour)	:	26.08	:	21.57
Turnover Rate (veh/space)	:	1.41	:	1.68
Duration (hour/veh)	:	4.70	:	4.81
Parking Load (%)	:	82.77	:	70.44

Table 4 shows a decrease in parking volume which means that the parking demand reduced. There is also an increase in the parking duration showing that a vehicle utilizes a parking stall for a longer period of time than compared to the past. The increase of the turnover rate indicates that the parking area is servicing more vehicles. The parking load suddenly declined. In effect, there are more available parking stalls for the employees.

3.5 Probability computation Day 2: January 9, 2012 (Monday)

Tables 5 reveals that all throughout the survey, the probability of finding an open parking space is equal to one which means that there is at least one vacant parking stall available. Between 8:31 to 8:45, the ratio of outgoing vehicles to incoming vehicles is 1:6 respectively which means 0.25% probability that there is no vehicle parked at that span of time. Thus, these 5 vehicles either did double parking and waited for an available parking space or went out of the campus.

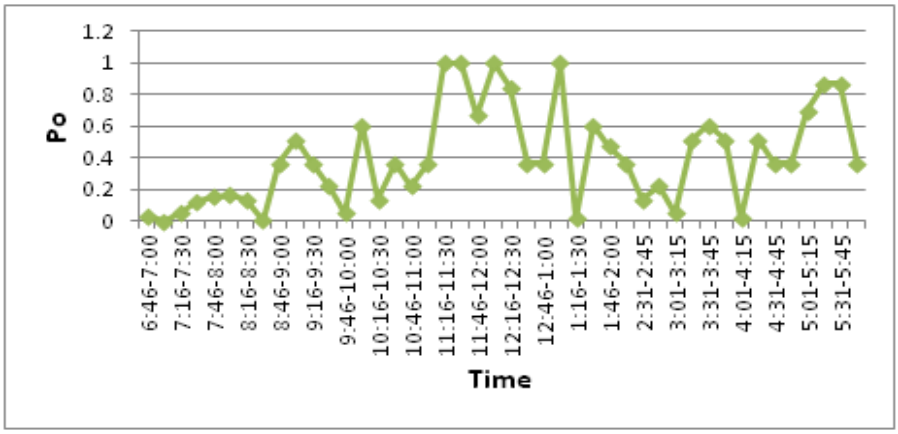

Figure 11. Probability of minimal vehicles parked (January 9, 2012)

Figure 11 shows the value of P_o fluctuates from 6:45 am to 6:00 pm. The probability of having fewer vehicles in the study area depends upon the arrival and departure patterns of the vehicles. The more vehicle arrival and less vehicle departure signify lesser vacant parking stalls. On the contrary, less vehicle arrival and more vehicle departure signify more parking stalls open for parking.

Table 5. Probabilities of parking with number coding scheme (Data: January 9, 2012)

Time	Inflow	Outflow	Po	P(n>N)	P
6:30-6:45	3	0	-	-	-
6:46-7:00	17	5	0.0334	4.2594x10-91	1
7:01-7:15	23	1	0	2.4656x10-18	1
7:16-7:30	21	7	0.0498	7.3773x10-49	1
7:31-7:45	21	10	0.1225	5.5420x10-50	1
7:46-8:00	13	7	0.1561	1.4657x10-29	1
8:01-8:15	9	5	0.1653	8.4629x10-24	1
8:16-8:30	2	1	0.1353	4.1823x10-18	1
8:31-8:45	6	1	0.0025	1.0885x10-07	1
8:46-9:00	3	3	0.3679	7.9584x10-21	1
9:01-9:15	2	3	0.5132	1.6235x10-18	1
9:16-9:30	2	2	0.3679	1.1722x10-15	1
9:31-9:45	3	2	0.2231	8.3020x10-12	1
9:46-10:00	3	1	0.0498	7.4496x10-07	1
10:01-10:15	1	2	0.6065	3.9424x10-22	1
10:16-10:30	2	1	0.1353	6.9266x10-13	1
10:31-10:45	1	1	0.3679	1.6801x10-19	1
10:46-11:00	3	2	0.2231	7.2464x10-13	1
11:01-11:15	2	2	0.3679	3.3800x10-18	1
11:16-11:30	0	2	1	0	1
11:31-11:45	0	5	1	0	1
11:46-12:00	2	5	0.6703	1.9429x10-32	1
12:01-12:15	0	4	1	0	1
12:16-12:30	1	6	0.8462	4.3662x10-41	1
12:31-12:45	3	3	0.3679	9.8821x10-28	1
12:46-1:00	2	2	0.3679	4.7824x10-35	1
1:01-1:15	0	2	1	0	1
1:16-1:30	4	1	0.0183	5.2698x10-15	1
1:31-1:45	2	4	0.6065	4.3942x10-37	1
1:46-2:00	3	4	0.4724	3.3772x10-37	1
2:01-2:15	0	0	-	-	-
2:16-2:30	4	4	0.3679	3.6488x10-29	1
2:31-2:45	4	2	0.1353	3.3269x10-19	1
2:46-3:00	3	2	0.2231	6.7580x10-21	1
3:01-3:15	3	1	0.0498	1.2592x10-11	1
3:16-3:30	2	3	0.5132	6.6034x10-26	1
3:31-3:45	2	4	0.6065	2.9920x10-30	1
3:46-4:00	2	3	0.5132	5.2807x10-29	1
4:01-4:15	4	1	0.0183	6.3703x10-11	1
4:16-4:30	4	6	0.5132	2.1877x10-24	1
4:31-4:45	4	4	0.3679	7.9584x10-21	1
4:46-5:00	4	4	0.3679	1.6801x10-19	1
5:01-5:15	5	14	0.6998	7.2773x10-43	1
5:16-5:30	2	14	0.8668	9.0749x10-73	1
5:31-5:45	1	7	0.8668	2.0327x10-87	1
5:46-6:00	1	1	0.3679	4.7461x10-49	1

3.6 Observed Parking Conditions

Faded parking guide markings leads to overlapping of vehicles. Thus, the capacity of the parking area is not usually maximized especially during at night and rainy seasons where driver's visibility is diminished as shown in Figure 12

.

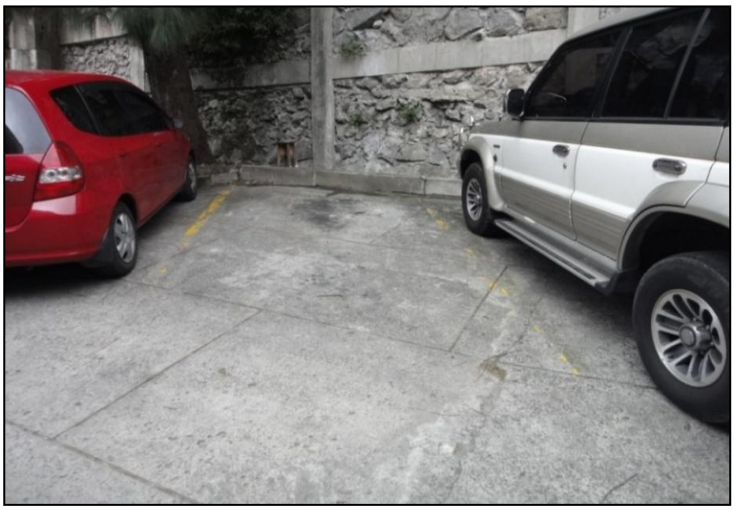

Figure 12. Faded parking guide markings

There are no pavement markings for the parking stalls at Parking Study Area F as shown in Figure 13. No parking guide markings confuse drivers where to position their vehicles in the parking area leading to insufficiency of parking availability.

Plant boxes and hollow blocks obstructed parking stalls which limits the space occupied by vehicles as shown in Figure 14a & 14b.

Figure 13. No parking guide markings

(a) (b)

Figure 14. Parking obstructions

Figure 15. Potential parking area

4. CONCLUSIONS

Based upon the findings, the study came up with the following conclusions:

a. Majority of the parked and registered vehicles have plate numbers ending in three (3), four (4), seven (7) and eight (8) as shown in Figures 4 and 5. Thus, Tuesdays and Thursdays are concluded to have the least parking usage among the school days. On the other hand, vehicles having plate numbers ending with one (1) and two (2) consist of the minority of the parked vehicles. Thus, Mondays are presumed to have the highest parking usage among the school days.
b. The number coding scheme implemented in the year 2012 provided the following results as shown in Table 4:

   a.1) It lessened the parking volume by 5 vehicles per hour (26.08-21.57=4.51) pointing out that the parking demand was reduced as shown in Table 4. The parking duration increased by 0.11 hour per vehicle (4.81-4.70=0.11) or 6.60 minutes per vehicle.

a.2) A rise in the turnover rate from 1.41 vehicles per space to 1.68 vehicles per space shows that the parking area was able to service more vehicles.

a.3) The parking load downsized from 82.77 percent to 70.44 percent with a difference of 12.53 percent indicating that there are more available parking spaces.

Hence, the implementation of the number coding scheme is effective.

c. At any time of the day, the probability that a vehicle not finding an open parking space is zero percent as shown in Table 5. This means that a driver can find at least one vacant parking stall. Thus, implementation of the number coding scheme is also effective.

5. RECOMMENDATIONS

These are recommended measures to further improve parking conditions in SLU Main Campus:

a. Utilization of parking spaces between the Centennial Park and Registrar's Office.
Additional parking stalls are necessary to increase the parking supply within the campus in order to address future increase in demand as shown in Figures 15.

b. Strict implementation of "One Car Sticker Pass per Employee."
"One Car Sticker Pass per Employee" is the policy for entry in the campus as per registration in the Student Affairs Office (SAO) in SLU. Some employees own more than one vehicle; thus, these employees use the unregistered vehicle when their registered vehicle is under the number coding. Thus, the policy is not strictly implemented. An annual check of registered vehicles by the SAO must be monitored to be fair with employees owning one vehicle. Moreover, old sticker pass should be surrendered upon owning a new vehicle for registration.

c. Practice Carpooling for employees who are couples.
Couples must practice carpooling instead of each one driving a vehicle going to work that contributes to insufficiency of parking availability.

d. Restoration of Parking Stalls.
The pavement markings for the parking stalls inside the campus are not that visible anymore, thus, repainting of the markings should be taken into consideration as shown in Figures 12 and 13.

e. Removal of Obstructions.
Remove obstructions such as hollow blocks or plant boxes in some parking stalls to maximize the use of the parking space as shown in Figure 14.

d. Employers in other establishments must consider implementing number coding scheme to improve their parking capacity and eventually contribute in the alleviation of traffic congestion in the CBD.

h. Evaluation of a color coding scheme instead of the number coding scheme for other countries. A color coding scheme instead of a number coding scheme maybe implemented to solve parking problems for other countries. A color coding scheme is a probable solution to solve uneven distribution of vehicles per day initiated by the number coding scheme since distribution of plate numbers are randomly issued by the Land Transportation Office (LTO) as shown in Figure 3. An example of a color coding scheme: Assuming 500 employees in a company each own a vehicle. This can be evenly distributed into 100 vehicles each day of the week. These vehicles are assigned by a color code and will not be allowed to park on that establishment on that particular day.

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APPENDICES

Sample Computations

1. Parking Statistics (January 6, 2012)

Parking Volume:

$$\text{Parking Volume} = \frac{\text{Total Vehicles Parked}}{\text{Observation Period}} = \frac{244 \text{ vehicles}}{11.5 \text{ hours}} = 21.22 \text{ veh/hour}$$

Turnover Rate:

$$= \frac{\text{Total Vehicles Observed}}{\text{Total Parking Spaces}} = \frac{244 \text{ vehicles}}{144 \text{ spaces}} = 1.69 \text{ veh/space}$$

Duration:

$$\text{Duration} = \frac{\text{Total vehicle-hour}}{\text{Total Vehicles}} = \frac{74430 \text{ minutes} \left(\frac{1 \text{ hour}}{60 \text{ minutes}}\right)}{244 \text{ vehicles}} = 5.08 \text{ hours/veh}$$

Parking Load:

$$\text{Parking Load} = \frac{\text{Total vehicle-hours}}{\text{Total space-hours}} = \frac{74430 \text{ minutes} \left(\frac{1 \text{ hour}}{60 \text{ minutes}}\right)}{244 \text{ vehicles } (11.5 \text{ hours})} \text{ x}100 = 74.91\%$$

2. Parking Probability (January 9, 2012)

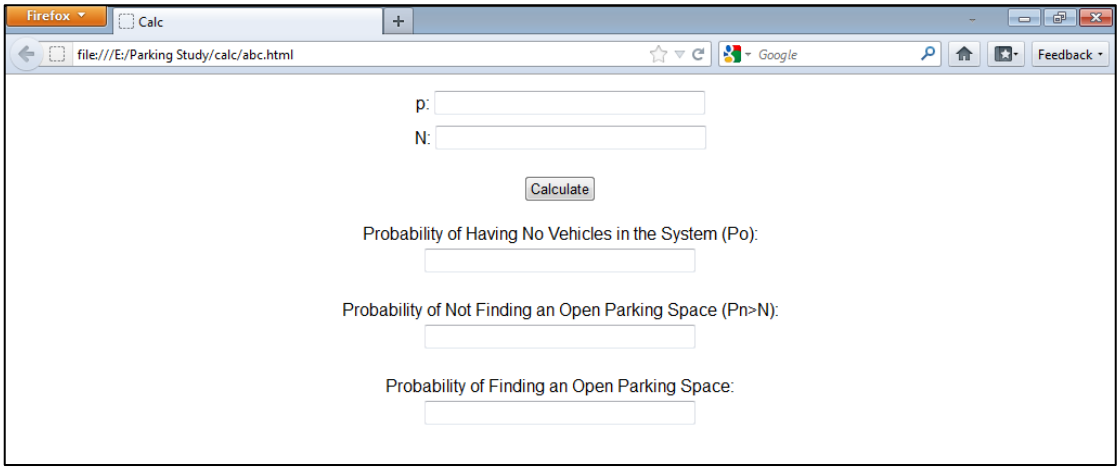
λ = 17 vehicles ; μ = 5 vehicles ; N = 88

$$\rho = \frac{\lambda}{\mu} = \frac{17 \text{ vehicles}}{5 \text{ vehicles}} = 3.40$$

$$\frac{\rho}{N} = \frac{3.40}{88}$$

$$\frac{\rho}{N} = 0.0386$$

Po is computed by a program:



Po = 0.0334

$$P_{n>N} = \frac{P_o\,(\rho^{N+1})}{N!N\,(1-\frac{\rho}{N})} = \frac{0.0334\,(3.40^{88+1})}{88!(88)(1-0.0386)} = 4.2594\text{x}10^{-91}$$

$P = 1 - P_{n>N}$

$P = 1 - 4.2594\text{x}10^{-91}$

$P = 1.0000$