[Parking]

Simulation Report

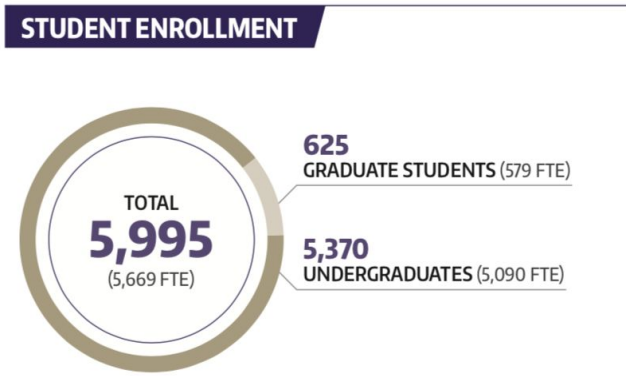
By Enter The [Matrix]

Adam Deehring
ajdeehr@uw.edu
Dewey Nguyen
duy3101@uw.edu
Ardalan Ahanchi
ardalan@uw.edu
Xavier Cheng
xavcheng@uw.edu

Introduction

Our team used a Monte Carlo Method to simulate the parking situation in UW Bothell, we used the class enrollment numbers we scraped from the UWB website, and then we generated some random samples based on those numbers. We simulate the parking situation for 30 school days (Monday to Friday). We investigated the parking utilization based on various conditions (i.e. a new West Parking, change class schedule), which we could be able to make plans to help the students get parking spots more easily and faster.

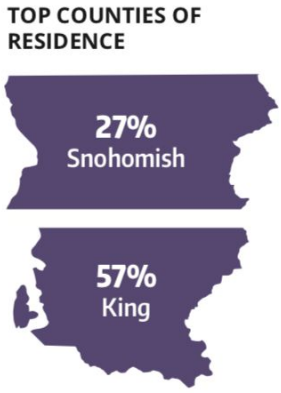
How many full-time student in UW Bothell ?

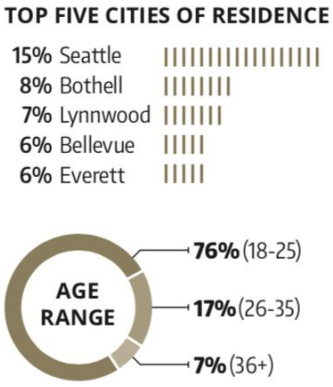


According to Fast Facts 2017-2018 (uwb.edu), there are 5,995 FTE students currently going to UWB.

15% of students live in Seattle, 8% of students live in Bothell, 7% of student live in Lynwood, 6% of students live in Bellevue and 6% of students live in Everett.

To conclude, there are only 8% of student living in the local area, while other students need to community to the campus.





The increasing number of commuters are putting pressure on the UWB administration as they are trying to build more parking spaces to accommodate current and future students.

How many students drive to school?

A survey conducted by Transpo Group in October 2018 ("Parking") showed that about 54% of student drive alone to campus, and about 9% of student carpool with others to school.

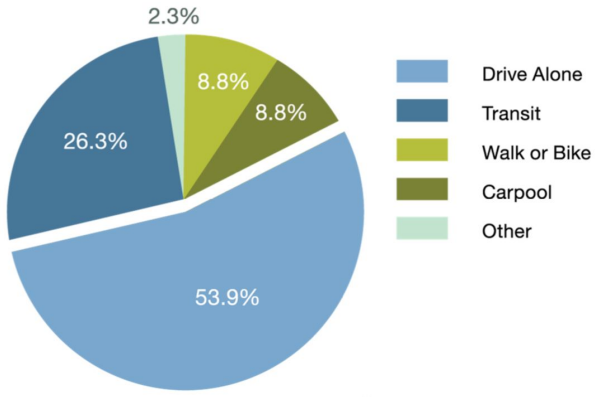


Figure 2 Campus Travel Mode Splits – 2018

How many parking spots available on Campus ?

PARKING LOT INVENTORY FY2018 - On-Campus Parking Lots												
Description	P	M	L	D	CP	R	MC	EV	E	V	Total	
CCC3 Loading Zone	0		2	2							4	
CCC1 Loading Zone	0										0	
UW1 South Loading Zone	0										0	
UW1 North Loading Zone	0										0	
UW2 Loading Zone	0		1								1	
South Campus Way Lot	40										40	*P = Permitted Spaces*
Chase House North	14	4		2							20	*M = (Coin) Meters*
Chase House South	18										18	*L = Loading*
Physical Plant	0			1					2	4	7	*CP = Carpool*
The Promenade	0										0	*MC = Motorcycle*
Campus Way NE	0	11	5	4					3	7	30	*E = Exempt*
North Creek Loading Dock	0										0	*V = Visitor*
Upper Surface Lot 1	87										87	*D = Disability*
Upper Surface Lot 2	128										128	*R = Reserved*
Upper Surface Lot 3	128										128	*EV = Electric Vehicles*
Upper Surface Lot 4	128										128	*S = Service Vehicles*
Upper Surface Lot 5	50										50	
Upper Surface Lot 6	50										50	
North Parking Garage	402			10	10	27	4	4			457	
South Parking Garage	704			20	23		8	12	4		771	
Truly Lot - Surface	137		1	1			8	2			149	
Sub - Total	1886	15	9	40	33	27	20	18	9	11	2068	

According to the Lot Inventory provided by the Transportation Services ("FY18"), there are total 2068 parking spots open to student, while some of them are for exempt vehicles or service vehicles, and some are special parking spots, the parking that available for students who drive alone is about 1900.

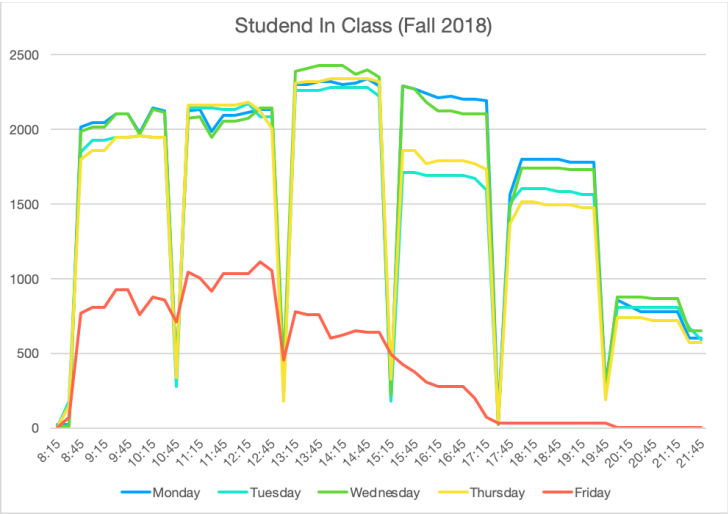
Is there enough parking spots on campus ?

Parking Lot	Parking Supply	Wednesday 10/24/2018 Demand	Wednesday 10/24/2018 Utilization	Thursday 10/25/2018 Demand	Thursday 10/25/2018 Utilization		Average Demand	Average Utilization	
11 AM									
North Campus Garage	451	427	95%	377	84%		402	89%	
South Campus Garage	774	747	97%	715	92%		731	94%	
Surface Lots	795	749	94%	678	85%		714	90%	
PUD Subtotal	**2,020**	**1,923**	**95%**	**1,770**	**88%**	**86%[1]**	**1,847**	**91%**	**90%[1]**
12 PM									
North Campus Garage	451	432	96%	400	89%		416	92%	
South Campus Garage	774	757	98%	739	95%		748	97%	
Surface Lots	795	763	96%	691	87%		727	91%	
PUD Subtotal	**2,020**	**1,952**	**97%**	**1,830**	**91%**	**79%[1]**	**1,891**	**94%**	**90%[1]**
1 PM									
North Campus Garage	451	408	90%	378	84%		393	87%	
South Campus Garage	774	702	91%	710	92%		706	91%	
Surface Lots	795	708	89%	685	86%		697	88%	
PUD Subtotal	**2,020**	**1,818**	**90%**	**1,773**	**88%**	**83%[1]**	**1,796**	**89%**	**87%[1]**
2 PM									
North Campus Garage	451	399	88%	368	82%		384	85%	
South Campus Garage	774	692	89%	687	89%		690	89%	
Surface Lots	795	711	89%	666	84%		689	87%	
PUD Subtotal	**2,020**	**1,802**	**89%**	**1,721**	**85%**	**81%[1]**	**1,763**	**87%**	**84%[1]**
3 PM									
North Campus Garage	451	384	85%	353	78%		369	82%	
South Campus Garage	774	618	80%	595	77%		607	78%	
Surface Lots	795	640	81%	541	68%		591	74%	
PUD Subtotal	**2,020**	**1,642**	**81%**	**1,489**	**74%**	**77%[1]**	**1,567**	**78%**	**81%[1]**

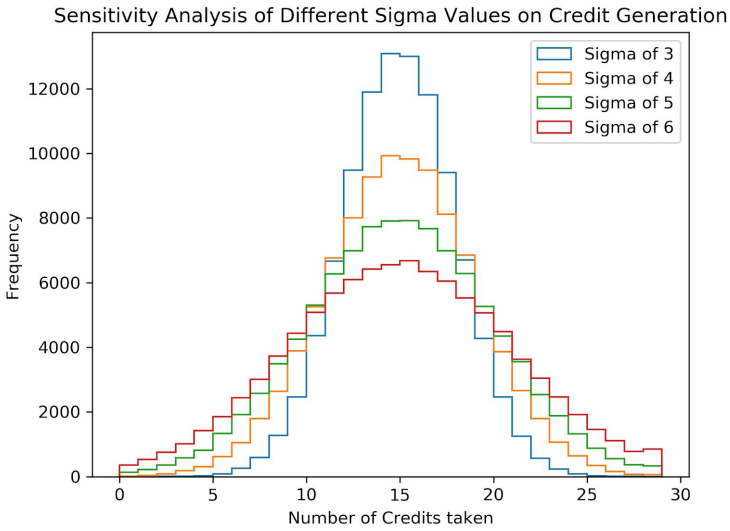
The survey conducted Transpo also showed the parking lot utilization throughout the day. From the table, we can see that the parking lot is nearly full at 11 am to noon. One thing that we need to point out is that the parking total included that special parking which might not be open to students.

How many students are in class every day ?

Our team created a program to scrape the quarter class enrollment of UWB, which indicated that at the peak hours, there are about 2500 students in class. With the student arriving early or staying after class, and visitors, faculty or staff parking on campus, the parking is way more saturated than the survey could show.

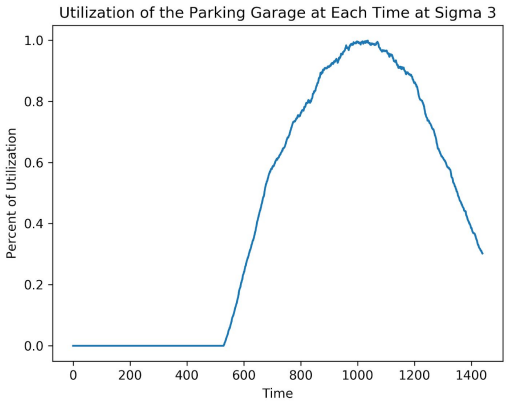


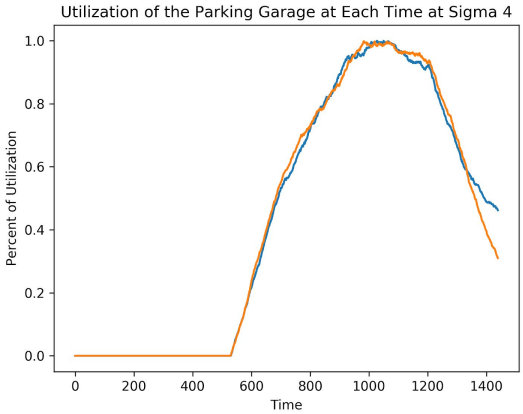
How are we going to simulate the number of students for every time step ?

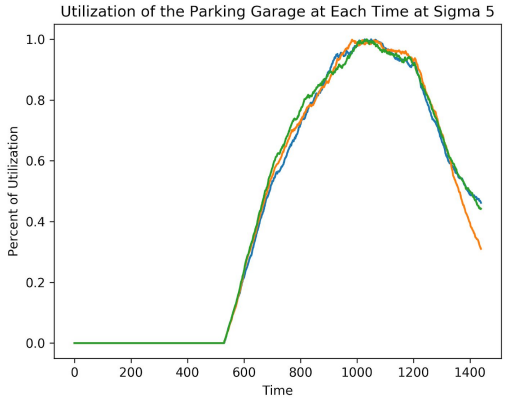


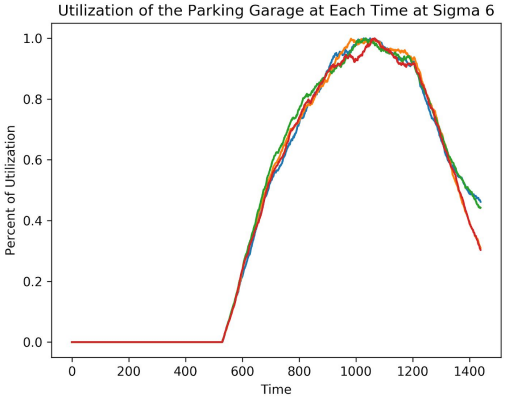
By using the data that we scraped from the time schedule at uwb.edu, we used the time schedule for Fall 2018, we can generate a normal distribution student's credit based on the proportion of the number of commuters data (the pie chart) that we said above. After getting a student's credit we can generate how long a student would stay on campus. As you can see on the sensitivity test above, we will use sigma 3,4,5, and 6 and see how they would differ in the simulation.

What is the utilization of the South Garage parking spot for every hour based on the sigmas that we used?



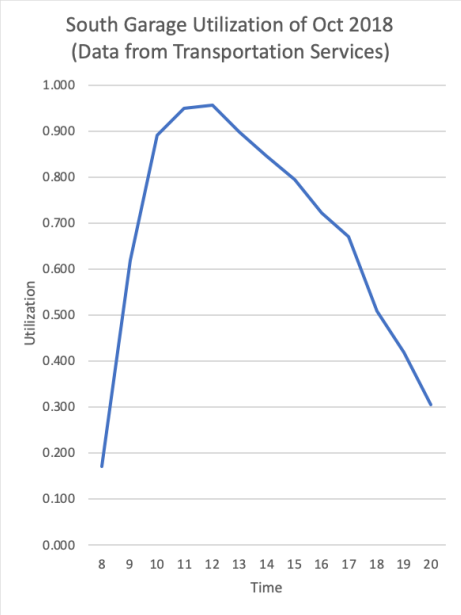






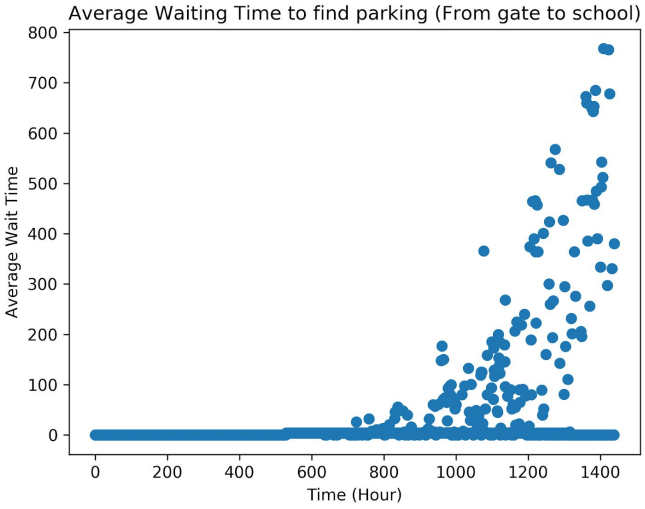
The x-axis represents the time step (minute) in the simulation (600 means its 10 am in the morning), you can see as we get to 720 to 840 (12 to 2 pm), the parking utilization gets more packed due to the incoming students. Unfortunately, our agent generation is not dynamic to the time step, we did not consider that the amount of hours a student would stay is correlated with the number of time step. For example, a student with 8 hours of time to stay at school is appropriate in the morning but it is not appropriate in the afternoon. We did not consider this relationship and therefore, our simulation keeps on generating students with long stay hours which make the student go home at late night hours.

What are the correlations between the simulation that we made and the real data that we scraped from the Transportation Center?

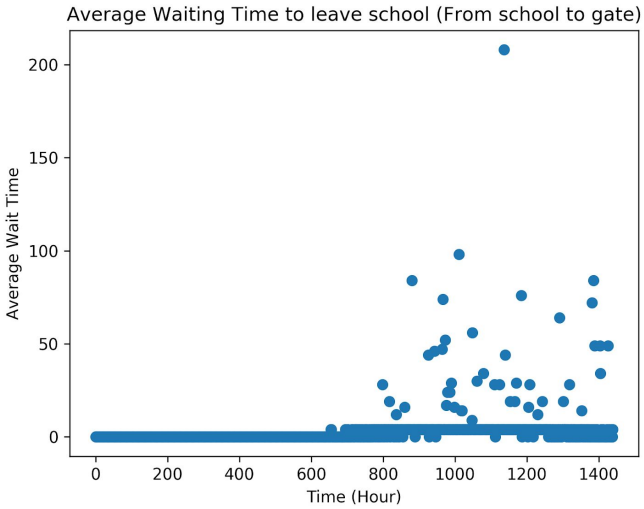


Xavier took the data that he scraped from the memo that we request from the Transportation Center and analyzed them by proportional the pie chart above (the same way that we generated the number of credits for each student). He came up with this graph, which correlates with the Parking Memo. This graph starts from 8 am to 8 pm. You can see the peak starts at 10 and starts going down at 2 pm

What is the average wait time for a student to find a parking spot and leaving school?

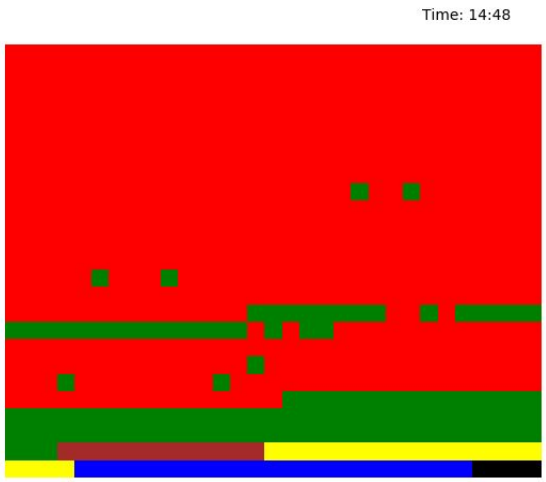


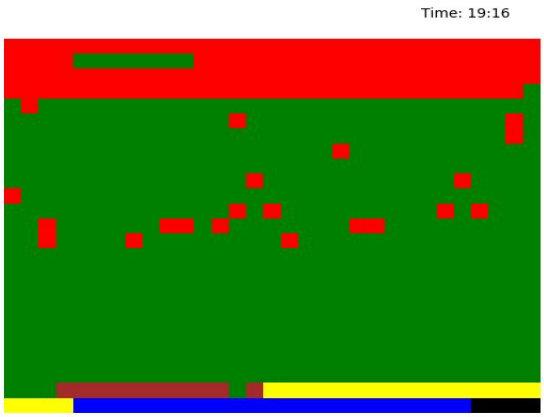
It looks like the waiting time to find a parking spot is minimal by looking at this graph. There are outliers that at a later stage of the parking but we couldn't find what went wrong. But overall, our Road module is working as intended and it's moving the Vehicle according to time step.



Similar to the waiting time, the lane going out of school is working as intended, you could see the outliers are happening very similar to the waiting time graph. We could not find a conclusive solution to these data.

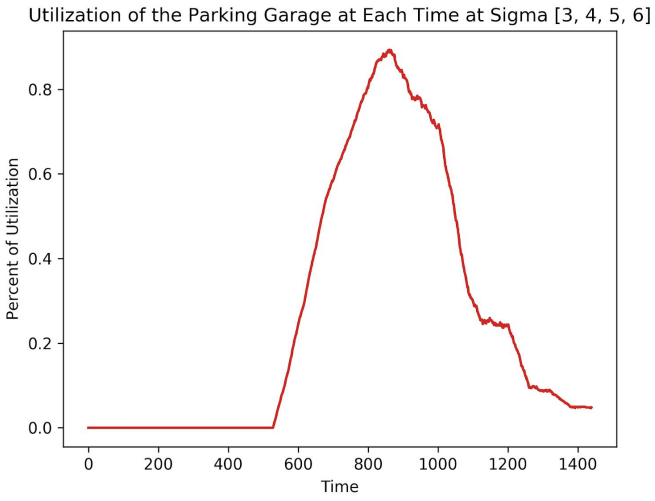
In terms of visualization, how does each vehicle park in and goes out of the garage?





We made a visualization for our South Parking garage to simulate how would the vehicles would park in the garage. The time on the right represents the time step in a minute. The red represents occupied spot by the vehicle, and the green represents unoccupied spot. Blue is handicapped, yellow is carpool and brown for motorcycle drivers

There are more rooms for improvement!



After our presentation to the class on Wednesday (6/5/2019), we decided to fix our student generator algorithm so that it is dynamic to the time step (the problem that we mentioned earlier). This graph shows the average of sigma (3,4,5,6) into one line. If we look at this graph and the graph that Xavier scraped from the Transportation Center. It is very similar. At step 800, which is around ~1 pm, we can see the parking utilization reach up to above 90%. The number of parking utilization is also rapidly decreasing after step 900 (3 pm). Finally, all the students should be leaving by the end of the day.

User Manual

1. Download EtM_ParkingSim.zip file from https://github.com/ajdeehr/EtM_ParkingSim
2. Numpy Module, BeautifulSoup4 module and the Matplotlib Module need to be installed on the machine
3. Once EtM_ParkingSim.zip has been downloaded and unzipped, Run scraping.py first, enter scraping(2018) (or any other year between 2013 and 2018).
4. Be sure that on_campus.csv is saved under the Data folder
5. To run the simulation, navigate over Model.py and run this file. It will run the simulation, visualizing the simulation, and the agents entering and leaving the garage. After this is done, Graphs will be generated, which will be png files with the prefix EtM_PS_…, in the Visualization folder.
6. Once Model.py has ran once, you can then navigate over to the Test folder, and run the Unit Tests.
7. Please refer to the README.txt file for more details on the file hierarchy, execution steps, and more information.