**Before Beginning**

My expected learning outcome derives from the conversations concerning this project that we had in class; I know that the CarWash project makes use of queues in order to handle the waiting line and feed cars into the washing bay, and therefore I expect to build on previous knowledge acquired in KQueue. This project will put to the test my ability to implement an LLQueue and my abilities to properly enqueue and dequeue objects while simultaneously keeping track of other data.

After skimming through the project guidelines, I see that the project expects the programmers to have a full understanding of how queue processing works.

I am expecting to extend the Car class, writing ArrivingCar, WaitingCar, and WashingCar, which each have different states depending on their position in the washing process. I also expect to modify the CarWashSimulation and Application classes.

Problems may arise when moving cars in and out of the bay; shifting objects with each looped step can sometimes get confusing, and I’m likely at some point to get some form of an off-by-one error.

**After Completion**

My actual learning outcome was precisely what I expected; this project was just an extension of the KQueue minilab. I also learned (the hard way) that ArrayLists cannot hold primitives…more on that topic in the problems section. As I wrote before, the project does a good job in extending lessons learned in the KQueue minilab. Practice makes perfect, and this project forced some much needed practice.

For some reason, even though LLQueue takes <T>, the enqueue() method can only enqueue Objects. Halfway through my project’s completion, I realized that every time I enqueued a Car into the waitingLine queue, it was converted to just an Object and lost the reference to its arrival time. I had to solve this by casting the returned object of dequeue() as a Car. However, I quickly learned that the ArrayList which I hoped to use to store the extracted waiting times of the dequeued cars would not hold plain integers, leading to issues when mixing wrapped integer objects and integers primitives in my average waiting time calculations. Instead I rely on an array which is created at the program start with enough indices to accommodate the generated cars.

**Analysis**

Pictures of my output can be found both in the submitted folder as well as in the latter pages of this document. Please note that the output displayed in the pictures does not match the text file output, as the data were captured in two different runs of the simulation. Included on the following two pages are 7 day simulations of the Squeaky Clean Car Wash using the old 4 minute cycle bay (Bay(4)) and the proposed new 3 minute cycle bay (Bay(3)), respectively. When using Bay(4), the average wait time was 15.02 minutes, whereas the average wait time when using the proposed Bay(3) is only 2.28 minutes. This is an improvement of 84.82%, where usage of Bay(3) results in cars waiting only 15.18% of their average 4 minute wait time. Furthermore, an average of 78 cars waited 10 or more minutes per day for Bay(4), as opposed to the 3 cars which waited for 10 or minutes for Bay(3). Installing the 3 minute wash bay is therefore a good investment and should result in fewer lost customers to excessive wait times. The optional project extension—installing two or more bays—was not implemented.

Squeaky Clean Car Wash -- Open 09:00 through 19:00 -- 1 bay / 4 minutes

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MONDAY

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Bay Wash Time: 4 | Total Num Cars: 143.0 | Total Waiting Time: 894.0 minutes

Average Wait Time: 6.25 minutes | Number of Cars Waiting 10+ minutes: 36 car(s)

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TUESDAY

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Bay Wash Time: 4 | Total Num Cars: 144.0 | Total Waiting Time: 2805.0 minutes

Average Wait Time: 19.48 minutes | Number of Cars Waiting 10+ minutes: 101 car(s)

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WEDNESDAY

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Bay Wash Time: 4 | Total Num Cars: 160.0 | Total Waiting Time: 5444.0 minutes

Average Wait Time: 34.03 minutes | Number of Cars Waiting 10+ minutes: 120 car(s)

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THURSDAY

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Bay Wash Time: 4 | Total Num Cars: 139.0 | Total Waiting Time: 1185.0 minutes

Average Wait Time: 8.53 minutes | Number of Cars Waiting 10+ minutes: 54 car(s)

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FRIDAY

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Bay Wash Time: 4 | Total Num Cars: 152.0 | Total Waiting Time: 1983.0 minutes

Average Wait Time: 13.05 minutes | Number of Cars Waiting 10+ minutes: 74 car(s)

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SATURDAY

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Bay Wash Time: 4 | Total Num Cars: 153.0 | Total Waiting Time: 2772.0 minutes

Average Wait Time: 18.12 minutes | Number of Cars Waiting 10+ minutes: 125 car(s)

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SUNDAY

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Bay Wash Time: 4 | Total Num Cars: 133.0 | Total Waiting Time: 757.0 minutes

Average Wait Time: 5.69 minutes | Number of Cars Waiting 10+ minutes: 34 car(s)

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Squeaky Clean Car Wash: Average Waiting Time only 15.02 minutes w/ one 4 min bay!

Squeaky Clean Car Wash -- Open 09:00 through 19:00 -- 1 bay / 3 minutes

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MONDAY

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Bay Wash Time: 3 | Total Num Cars: 145.0 | Total Waiting Time: 203.0 minutes

Average Wait Time: 1.4 minutes | Number of Cars Waiting 10+ minutes: 0 car(s)

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TUESDAY

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Bay Wash Time: 3 | Total Num Cars: 158.0 | Total Waiting Time: 481.0 minutes

Average Wait Time: 3.04 minutes | Number of Cars Waiting 10+ minutes: 3 car(s)

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WEDNESDAY

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Bay Wash Time: 3 | Total Num Cars: 142.0 | Total Waiting Time: 217.0 minutes

Average Wait Time: 1.53 minutes | Number of Cars Waiting 10+ minutes: 0 car(s)

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THURSDAY

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Bay Wash Time: 3 | Total Num Cars: 141.0 | Total Waiting Time: 187.0 minutes

Average Wait Time: 1.33 minutes | Number of Cars Waiting 10+ minutes: 0 car(s)

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FRIDAY

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Bay Wash Time: 3 | Total Num Cars: 157.0 | Total Waiting Time: 388.0 minutes

Average Wait Time: 2.47 minutes | Number of Cars Waiting 10+ minutes: 1 car(s)

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SATURDAY

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Bay Wash Time: 3 | Total Num Cars: 162.0 | Total Waiting Time: 619.0 minutes

Average Wait Time: 3.82 minutes | Number of Cars Waiting 10+ minutes: 13 car(s)

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SUNDAY

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Bay Wash Time: 3 | Total Num Cars: 157.0 | Total Waiting Time: 368.0 minutes

Average Wait Time: 2.34 minutes | Number of Cars Waiting 10+ minutes: 3 car(s)

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Squeaky Clean Car Wash: Average Waiting Time only 2.28 minutes w/ one 3 min bay!



