Noun Verb Analysis

The task is to develop a simulation of a self-service petrol station with a certain number of pumps and a shop. Different types of vehicles may come to the station to top up, (optionally) pick up some food and necessities and then pay for everything at one of the tills. The purpose of the simulation is to study what level of demand can be handled with a certain number of pumps and tills, keeping customers happy and net income high. All value ranges mentioned are uniformly randomly distributed.

You will have various types of vehicles:

- Small cars have 7–9 gallon tanks, and take up 1 unit of space in the queue.
- Motorbikes take up 0.75 units of space in the queue, and their gas tanks are smaller (5 gallons).
- Family sedans take up 1.5 units of space in the queue, and their gas tanks are larger (12–18 gallons).

Note that the probabilities of the purchases, the sizes of the gas tanks and their behaviour are subject to change in the future. You should make your classes flexible enough to adapt to this without major alterations to the software.

Your simulation should model the petrol station with a time resolution of 10 seconds (1 "tick"). The system has the following configuration:

1. There is a configurable number of pumps. Each pump has a queue that can fit up to 3 units of space (e.g. 2 sedans, 3 small cars or 4 motorbikes). Pumps provide 1 gallon per tick of fuel.
2. There is a configurable number of tills in the shop. Paying at the till takes 2–3 minutes.
3. Small cars and motorbikes arrive with a probability of p per tick.
4. Family sedans arrive with a probability of q per tick.
5. Customers always go to one of the least occupied queues first (both for pumps and for tills).
6. If a vehicle arrives and does not fit into any of the queues, the vehicle will simply leave.
7. Vehicles always fully top up their tanks. By default, one gallon is £1.20 for the simulation.
8. Vehicles stay in the queue for the pump while the driver goes to the shop to pay at the till.
9. The vehicle starts topping up on the next tick after it gets to the front of the queue for the pump, and the driver goes to the till on the next tick after it tops up.
10. You must track how much money was earned, and how much money was lost because of vehicles being unable to enter the station.
11. You must write test classes in JUnit 4 for at least five of your classes.

There is a second set of requirements that you will need to complete for full marks:

1. A graphical user interface should be provided and allow the user to set values such as p and q, the price of the gallon, and the period of time that the simulation should run for.
2. You must also simulate a shopping area in the gas station. Happy customers that refill quickly will spend some time looking around (away from the tills), before queueing up at a till on the next tick and paying some additional money:

- For small cars, if the refill is done in less than 5 minutes since arriving, there is a probability of 0.3 that the driver will shop for 2–4 minutes to spend an extra £5–£10.

- For family sedans, if the refill is done in less than 10 minutes since arriving, there is a probability of 0.4 the driver will shop for 2–5 minutes to spend another £8–£16.
- Motorbike drivers in the area are thrifty and will never go to the shopping area.

You will need to track the money lost from missed sales as well. It may be interesting to track it separately from the money gained from selling fuel.

3. Trucks may also arrive at the station. They take up 2 units of space. After refilling their 30–40 gallon tank, a truck driver that refilled in 8 minutes or less will always do a purchase of £15-£20 after browsing for 4–6 minutes.
An unhappy truck driver will let the other truck drivers know about the bad service. This will make it less likely that they come. Trucks arrive with a probability of t, which is initially $t_0 = 0:02$. An unhappy truck driver will reduce t by 20% of its current value: $t_0 = 0:8t$. A happy truck driver will increase it by 5% of its current value, up to the original value of t: $t_0 = minf1:05t; t_0g$.

Goal Information

The aim of running the simulation is to decide for each station configuration (number of pumps and tills) which level of activity it is best suited for: that is, which are the values of p and q that report the highest net income (raw income minus missed sales).

To do this, the simulation should be run for four hours (1440 ticks) for all independent combinations of the values below, and the results should be averaged over 10 different seeds for the random number generator:

- p: 0:01, 0:02, 0:03, 0:04, and 0:05.
- q: same options as p.
- Pumps: 1, 2 and 4.
- Tills: 1, 2 and 4.
- With and without trucks (if implemented).

For full marks, you should run separate studies with and without trucks. The owners of the gas station
are currently wondering if they should allow trucks to refill at the station or not, so you should compare
for each station configuration if it is better to allow trucks or not.

Goals:

Track money spent – via pump and till separately
Track money lost - via pump and till separately
Track customer happiness
Run Simulations with a different amount of tills and pumps (within boundaries)
Run Simulations with trucks enables or disabled
Conclude what setups are best of trucks enabled

Objects:

Petrol station has pumps and shopping area
Pumps have a queue and provide fuel via tick
Vehicles have different size tanks that take up spaces in a queue
Shopping area has food with tills

Behavior:

Vehicles queue at pumps
Vehicles still queue while paying at the till if buying food)
Vehicles fill up fuel first before potentially buy food in the shop
Vehicles queue at the least occupied pump
If there is not enough space for a vehicle it will leave and the potential losses are added to a tally
Happy customer vehicles (except motorbikes) will shop for food in the shop adding to pump queue time
Purchase are made at the till in the shop but petrol and food are tallied separately
Unhappy truck drivers will reduce the probability of trucks arriving while happy trucks will increase it

Vehicle Class differences

Type	Arrival Chance	Size (Pump Units)	Tank Size (Gallons)	Max fill time	Shopping Ability	Shopping Probability (0-1)	Shopping Time (Minutes)	Shopping Spend (£)
MotorBike	P	0.75	5	N/A	No	N/A	N/A	N/A
Small Car	p	1	7-9	<=5	Yes	0.3	2-4	5-10
Family Sedan	q	1.5	12-18	<=10	Yes	0.4	2-5	8-16
Truck	t	2	30-40	<=8	Yes	1	4-6	15-20

CRC Cards

Vehicle (motorbike, small car, family sedan, truck)	
- Type of Vehicle - Tank Size - Fill Time - Size - Track and adjust Happiness, based on fill time - Max queue + fill time for happiness - Determine based on happiness whether they will shop - Hold Shop Time - Calculate Shop Spend - Maximum/Minimum shop spend range	Petrol Station Pump Till

Petrol Station	
- Number of tills - Number of Pumps - Simulate a shopping area - Track overall Happiness Level - Track Pump Sales - Track Shop Sales - Track the Missed Sales - Track the Completed Sales	Vehicle Pump Till

Pump	
- Holds a queue of Vehicles - Maximum size - Tracks Space used by Vehicles	Petrol Station Vehicle Till

Till	
- Holds a queue of Customers	Petrol Station Pump Vehicle

Potential Further Ideas

1. Track sales from each separate vehicle to see what setup if the best for max potential sales.
2. Change Payment to pump if customer is unhappy
3. Change Pumps to only take a certain type of vehicle
4. Change Vehicles to go to pumps full so it amounts as close to the maximum fill space as possible