Calculating maximum capacity of the road network

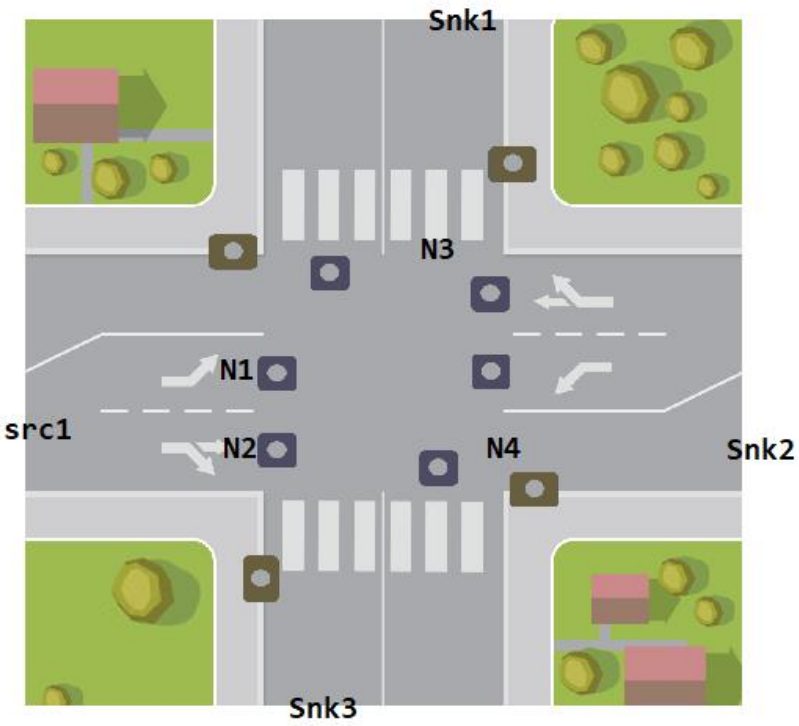
Assumptions:

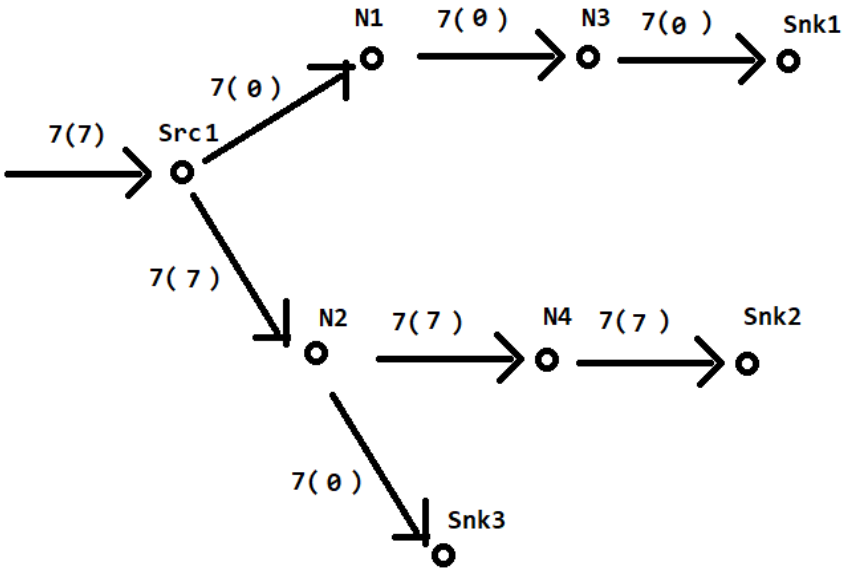
- Simulation is running smoothly
- There are no crashes

To calculate the maximum capacity we have to use the Ford-Fulkerson algorithm. Because the road network may vary I can't make a graph out of it so I will look at each road to see what its graph looks like. To create a network out of the roads we have in the simulation, I have to separate the lanes each road too. The road map is separated into a 3x3 grid. Each side of each square on the grid is equal to 7 of the cars. Each square is separated into either 1, 2 or 3 lanes depending on the type of lane. Sources, Sinks and nodes are placed on the sides of the squares. This separation and structure is required to be able to make directed graph with edges with capacity.

Road type 1

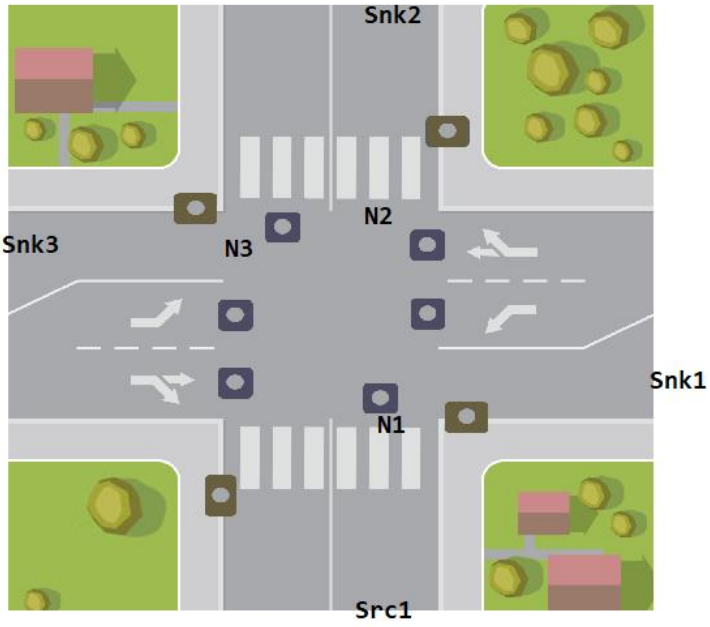
Lane type 1

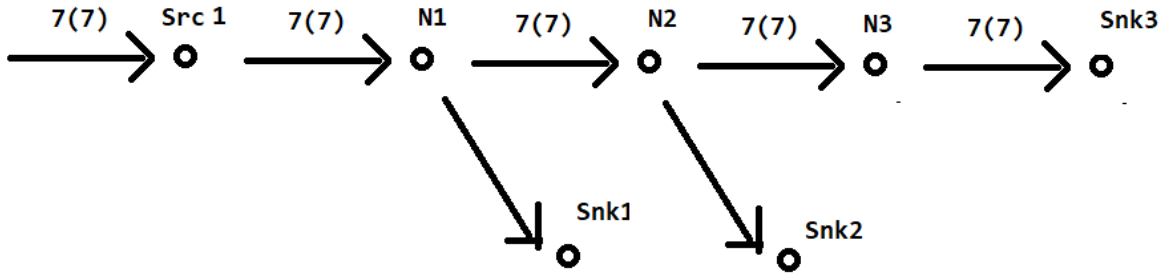




As we can see the first lane has a capacity of 7 cars no matter what path we choose. When the traffic light turns green on N2, 7 cars pass before the traffic light turns red. New cars spawn after them filling again the space between Src1 and N2. The cars that moved are now between N2 and N4. As the cars move from N4 to Snk2 there are no cars to follow them so between N2 and N4 the traffic is 7(0). At that time the traffic light of the second type of lane turn green.

Lane type 2





As we can see from this graph, the result is the same. There is a constant pool of cars between Src1 and N1, at most 7 between N1, N2 and N3 – this space is filled when lane type 1 cars enter the last edge, and at most 7 cars at the last edges.

The maximum capacity of this road is calculated by using the formula:

$$N_c\,(p) = N_{cell} * p_c(N)$$

$N_c\,(p)$ – Maximum capacity

N_{cell} - Number of cells (each lane has number of cells. For our simulation there are 7 cells for each lane and each cell is equal to the size of 1 car)

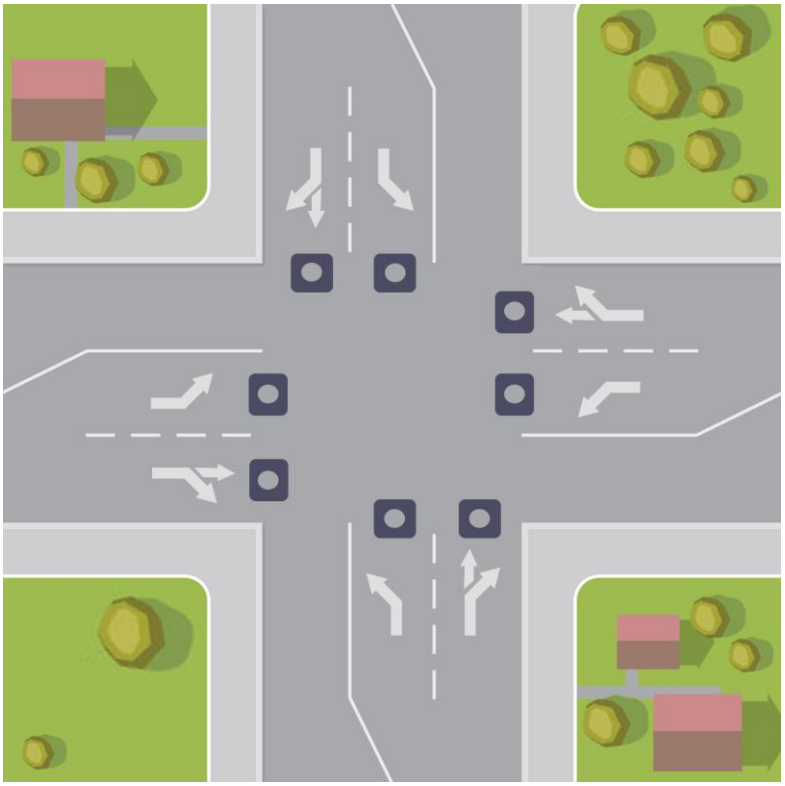
$p_c(N)$ – Critical density (calculated by dividing the area of a cell by the number of cars on it. Since our cells are the area of a single car our density is 1. This is as real as we can get.)

We found that lane type 1 between Src and first N has a capacity of 7. The mid section of the intersection has a capacity of 14 since at once there are two lanes that have traffic lights showing green. From the last nodes to the Sinks there is a capacity of 7 again. The same goes for lane type 2. So to calculate the maximum capacity of this road we have:

*N_c (p) = N_{cell} * 1 = 4*7(4 sources of the road * 7 cells for each lane) + 2x7(the midsection at most 2 lanes can enter it with 7 cars each making 14 cells) + 2*7 (as 2 last edges can be filled at once) = 56*

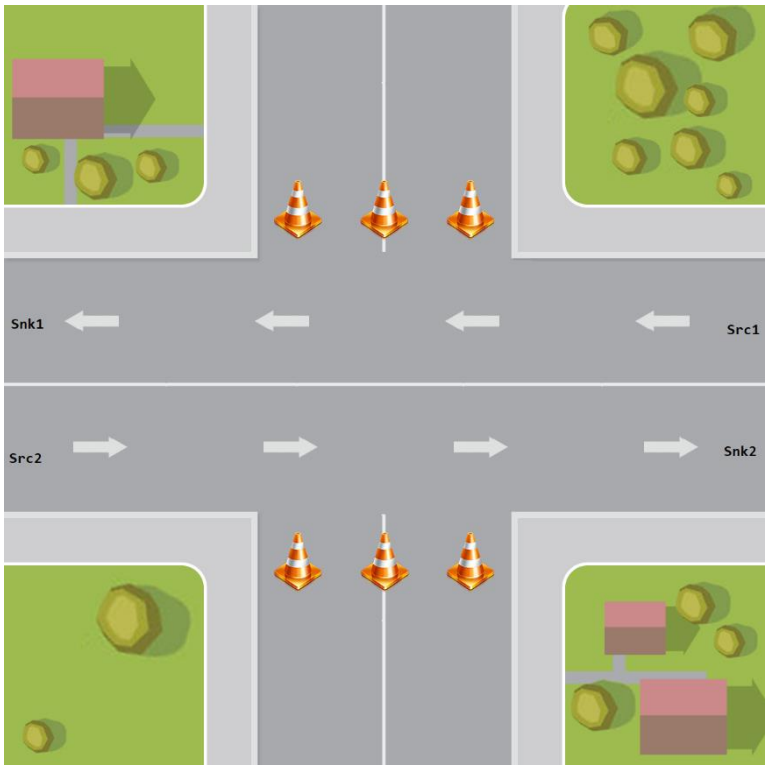
Road type 2

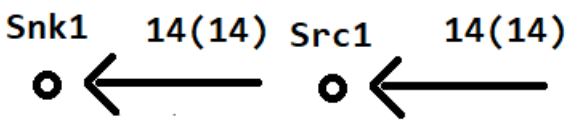
This type of road has only type 1 lanes which I already explained. The calculation for this road is the same and its capacity is also 56.



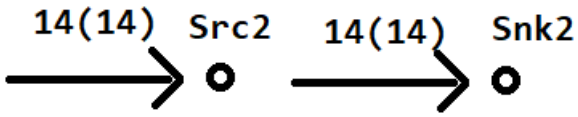
Road type 3

Because on this type of road we have no traffic lights, there is nothing to stop the cars or diverge their way to the sink. Because of this we have cars having their initial distance between each other and thus the maximum capacity of one lane on this road is the maximum amount of cars that can move from Scr1 to Snk1 at the same time. From the simulation we can see that we have 14 cells on each lane so the total N_c *(p)* will be 14*2. There is no change at the maximum capacity when this road is turned at 90 degrees - when it becomes vertical.

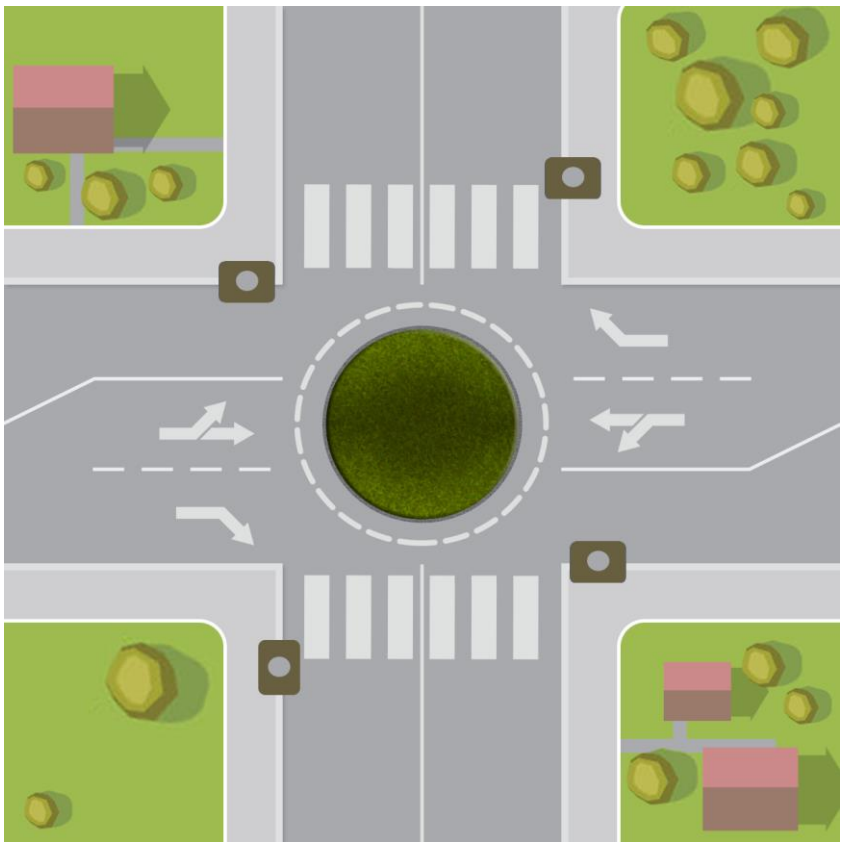




Road type 4



On the roundabout we have the 2 types of lanes which are explained above. The difference is in the middle section where we have a roundabout and not an intersection. Also here we do not have traffic lights but to get as realistic as possible we have to assume that the cars wait if the roundabout is full so no crashes occur. Although it is a roundabout it is in the middle section so it again has 2*7 cells and thus the middle section capacity is equal to the cells. The difference here is that because it's a roundabout there can be cars going to all the Sinks simultaneously. So to calculate N_c *(p)* we add 4 edges from the source each of which has 7 cells, 4 edges to the Sinks that have 7 cells each and 2*7 cells in the middle section. This makes a total N_c *(p) = 4*7+4*7+2*7 =70*



Conclusion

We found the capacity of each lane then added them to find the capacity of each road and to find the total capacity of the whole road network we just have to add the capacities of all the roads on the grid.