جامعة الأخوين

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AL AKHAWAYN UNIVERSITY

School of Science and Engineering

CSC 3351
Operating Systems

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Assignment 1: Report

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Introduction:

In this assignment, we used the C library, pthread, to create and simulate traffic over a narrow light-duty bridge. Upon running the program, 20 threads are created with each one representing one vehicle. The vehicles must be synchronized to cross the bridge.

The bridge can be crossed bi-directionally, although, vehicles going in opposite directions cannot cross it simultaneously. Furthermore, the bridge cannot support more than three vehicles.

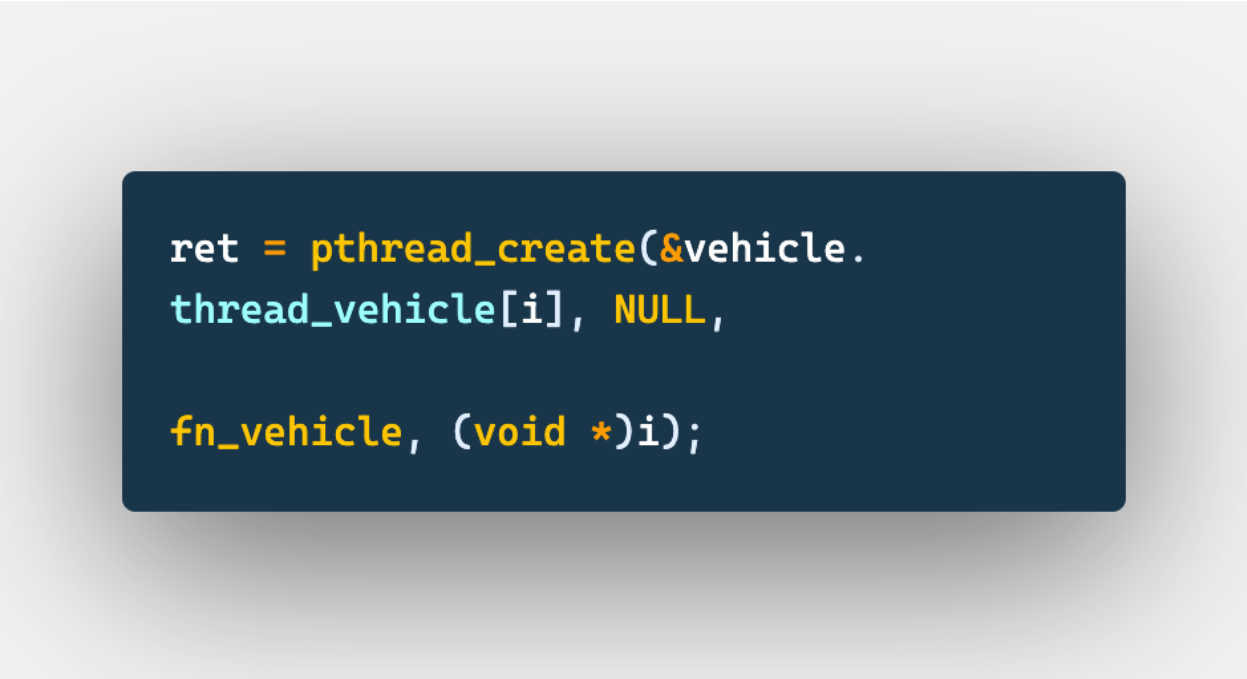
Pthreads:

Pthreads is a standardized model for dividing a program into subtasks whose execution can be interleaved or run in parallel. The "P" in Pthreads comes from POSIX (Portable Operating System Interface), the family of IEEE operating system interface standards in which Pthreads is defined (POSIX Section 1003.1c).

We want to design a program so that it executes in multiple threads within a process. Therefore, we need a thread creation routine and a way of letting the new thread know where in the program it should begin executing.

We will detail the Pthread functions used in this report before running the program.

Thread Creation: We create our threads using the function:
Pthread_create.



In our code we passed the following arguments to the function:

A pointer to a buffer to which pthread_create returns a value that identifies the newly created thread. This value is of type pthread_t.*

A pointer to the routine fn_vehicle, at which the new thread will start executing.

A pointer to a parameter to be passed to the routine at which the new thread starts.

The function returns 0 in case of success. We stored this value to check for creation success.

fn_vehicle:

```
static void *fn_vehicle(void *p_data)
{
    vehicle.vehicle_id = (int)p_data;
    vehicle.dir =
get_random_direction();
    vehicle.time_to_cross = 1;

    while (1)
    {
        printf("Vehicle %d
 has arrived at the bridge\n",
               vehicle.vehicle_id);
        oneVehicle(vehicle.vehicle_id
, vehicle.dir, vehicle.time_to_cross
);
        pthread_exit(vehicle.
thread_vehicle[vehicle.vehicle_id]);
    }
    return NULL;
}
```

Each one of the threads executes the oneVehicle function, as specified in the assignment specifications.

Now remains the issue of synchronizing the threads, which is done using the oneVehicle function in the code.

Let's run the code!

```
Please choose the vehicle arrival schedule
            Enter 1 for: 5 : DELAY(10) : 5 : DELAY(10) : 5 : DELAY(10) : 5
            Enter 2 for: 10 : DELAY(10) : 10
            Enter 3 for: 20
            choice:
```

Upon running the code, we are given a choice between three vehicle arrival schedules. We will take snapshots of each schedule. To see the program in action, it is recommended to run the code.

1)

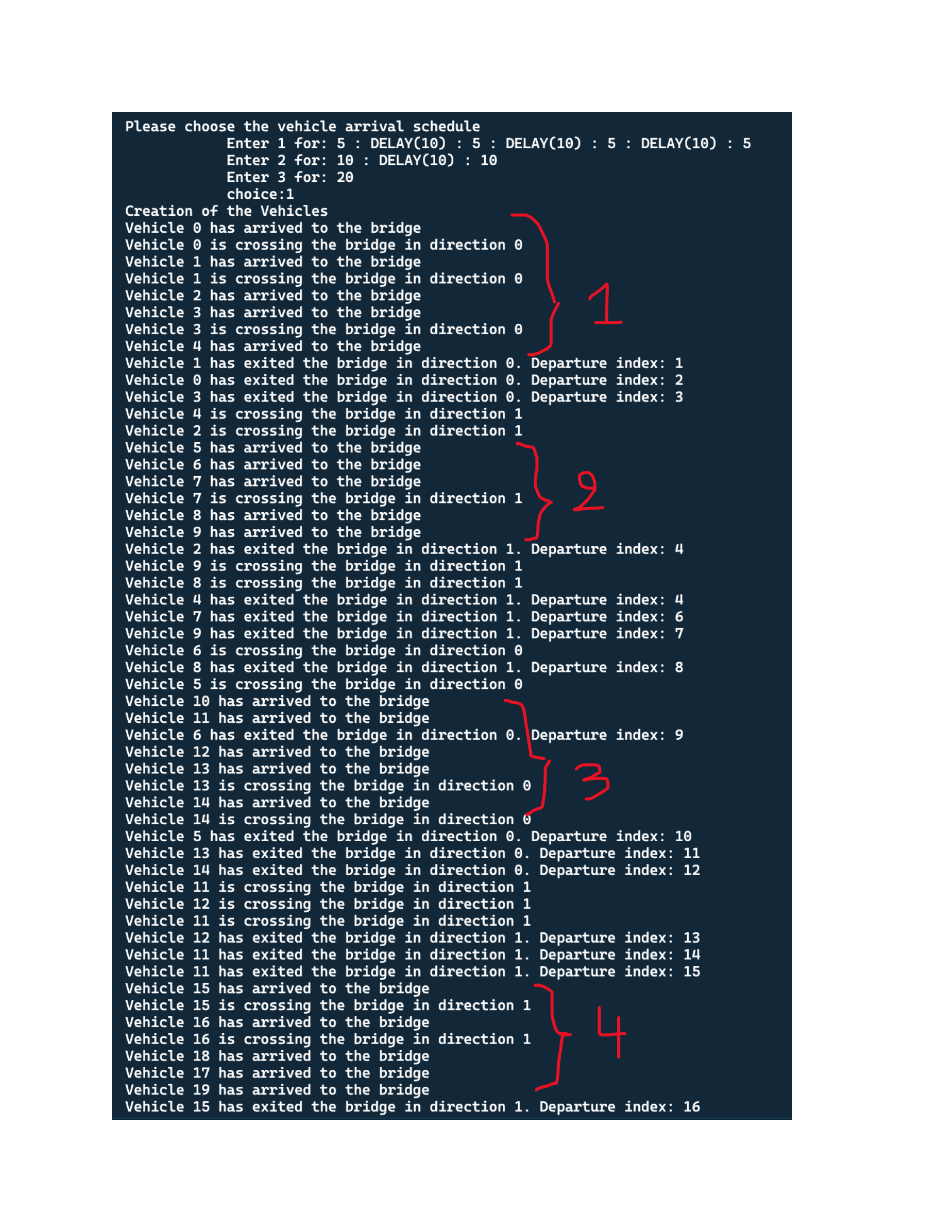
The 20 vehicles arrive in four groups of 5. Each with a 10 second delay. We can see the first vehicle, 0, cross the bridge as soon as it arrives, as the bridge is empty. Interestingly, vehicle 2 arrives to the bridge but doesn't cross it. This is because it is coming from direction 1, while the bridge is being crossed by vehicles arriving from direction 0.

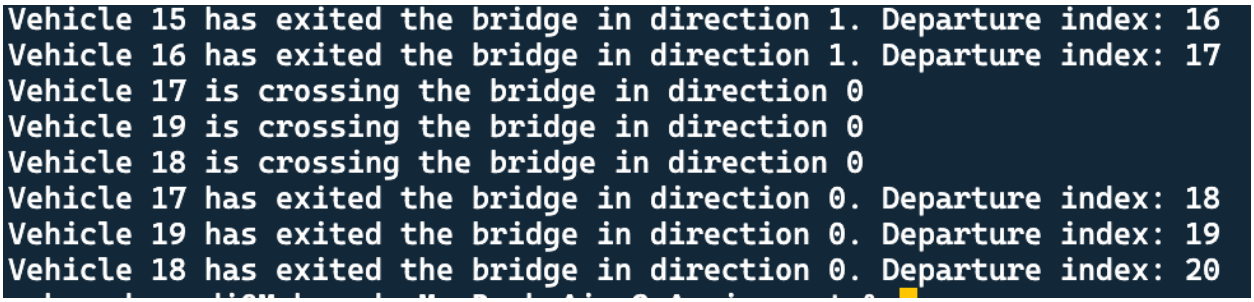
The arriveBridge function allows for the organization of the vehicles crossing based on their direction, as it returns only when it is safe for the vehicles to cross.

After the direction 0 vehicles from the first group crossed the bridge, the direction 1 vehicles take their turn to cross. This is while the second group of vehicles arrived after the 10 seconds elapsed. As such, the direction 1 vehicles from the second group cross the bridge first.

Each vehicle takes 5 seconds to cross the bridge implemented in the crossbridge function. Lastly exitBridge indicates that the vehicle has completed the crossing and exits the thread. Furthermore, it keeps track of the departure index for each vehicle.

```
Please choose the vehicle arrival schedule
            Enter 1 for: 5 : DELAY(10) : 5 : DELAY(10) : 5 : DELAY(10) : 5
            Enter 2 for: 10 : DELAY(10) : 10
            Enter 3 for: 20
            choice:1
Creation of the Vehicles
Vehicle 0 has arrived to the bridge
Vehicle 0 is crossing the bridge in direction 0
Vehicle 1 has arrived to the bridge
Vehicle 1 is crossing the bridge in direction 0
Vehicle 2 has arrived to the bridge
Vehicle 3 has arrived to the bridge
Vehicle 3 is crossing the bridge in direction 0
Vehicle 4 has arrived to the bridge
Vehicle 1 has exited the bridge in direction 0. Departure index: 1
Vehicle 0 has exited the bridge in direction 0. Departure index: 2
Vehicle 3 has exited the bridge in direction 0. Departure index: 3
Vehicle 4 is crossing the bridge in direction 1
Vehicle 2 is crossing the bridge in direction 1
Vehicle 5 has arrived to the bridge
Vehicle 6 has arrived to the bridge
Vehicle 7 has arrived to the bridge
Vehicle 7 is crossing the bridge in direction 1
Vehicle 8 has arrived to the bridge
Vehicle 9 has arrived to the bridge
Vehicle 2 has exited the bridge in direction 1. Departure index: 4
Vehicle 9 is crossing the bridge in direction 1
Vehicle 8 is crossing the bridge in direction 1
Vehicle 4 has exited the bridge in direction 1. Departure index: 4
Vehicle 7 has exited the bridge in direction 1. Departure index: 6
Vehicle 9 has exited the bridge in direction 1. Departure index: 7
Vehicle 6 is crossing the bridge in direction 0
Vehicle 8 has exited the bridge in direction 1. Departure index: 8
Vehicle 5 is crossing the bridge in direction 0
Vehicle 10 has arrived to the bridge
Vehicle 11 has arrived to the bridge
Vehicle 6 has exited the bridge in direction 0. Departure index: 9
Vehicle 12 has arrived to the bridge
Vehicle 13 has arrived to the bridge
Vehicle 13 is crossing the bridge in direction 0
Vehicle 14 has arrived to the bridge
Vehicle 14 is crossing the bridge in direction 0
Vehicle 5 has exited the bridge in direction 0. Departure index: 10
Vehicle 13 has exited the bridge in direction 0. Departure index: 11
Vehicle 14 has exited the bridge in direction 0. Departure index: 12
Vehicle 11 is crossing the bridge in direction 1
Vehicle 12 is crossing the bridge in direction 1
Vehicle 11 is crossing the bridge in direction 1
Vehicle 12 has exited the bridge in direction 1. Departure index: 13
Vehicle 11 has exited the bridge in direction 1. Departure index: 14
Vehicle 11 has exited the bridge in direction 1. Departure index: 15
Vehicle 15 has arrived to the bridge
Vehicle 15 is crossing the bridge in direction 1
Vehicle 16 has arrived to the bridge
Vehicle 16 is crossing the bridge in direction 1
Vehicle 18 has arrived to the bridge
Vehicle 17 has arrived to the bridge
Vehicle 19 has arrived to the bridge
Vehicle 15 has exited the bridge in direction 1. Departure index: 16
```

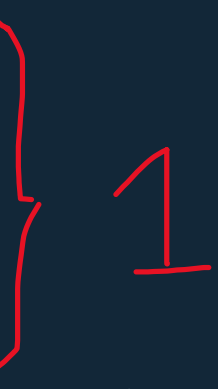


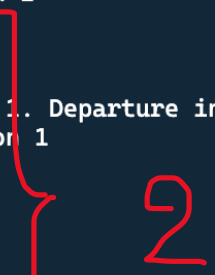


2)

Same experiment only the vehicles are split into two groups with the second group arriving following a 10 second delay.

```
Please choose the vehicle arrival schedule
            Enter 1 for: 5 : DELAY(10) : 5 : DELAY(10) : 5 : DELAY(10) : 5
            Enter 2 for: 10 : DELAY(10) : 10
            Enter 3 for: 20
            choice:2
Creation of the Vehicles
Vehicle 0 has arrived to the bridge
Vehicle 0 is crossing the bridge in direction 0
Vehicle 1 has arrived to the bridge
Vehicle 2 has arrived to the bridge
Vehicle 3 has arrived to the bridge
Vehicle 3 is crossing the bridge in direction 0
Vehicle 4 has arrived to the bridge
Vehicle 5 has arrived to the bridge
Vehicle 5 is crossing the bridge in direction 0
Vehicle 6 has arrived to the bridge
Vehicle 7 has arrived to the bridge
Vehicle 8 has arrived to the bridge
Vehicle 9 has arrived to the bridge
Vehicle 0 has exited the bridge in direction 0. Departure index: 1
Vehicle 3 has exited the bridge in direction 0. Departure index: 2
Vehicle 5 has exited the bridge in direction 0. Departure index: 3
Vehicle 2 is crossing the bridge in direction 1
Vehicle 4 is crossing the bridge in direction 1
Vehicle 2 is crossing the bridge in direction 1
Vehicle 10 has arrived to the bridge
Vehicle 11 has arrived to the bridge
Vehicle 12 has arrived to the bridge
Vehicle 2 has exited the bridge in direction 1. Departure index: 4
Vehicle 12 is crossing the bridge in direction 1
Vehicle 13 has arrived to the bridge
Vehicle 14 has arrived to the bridge
Vehicle 15 has arrived to the bridge
Vehicle 16 has arrived to the bridge
Vehicle 17 has arrived to the bridge
Vehicle 18 has arrived to the bridge
Vehicle 19 has arrived to the bridge
Vehicle 4 has exited the bridge in direction 1. Departure index: 5
Vehicle 9 is crossing the bridge in direction 1
Vehicle 2 has exited the bridge in direction 1. Departure index: 6
Vehicle 8 is crossing the bridge in direction 1
Vehicle 12 has exited the bridge in direction 1. Departure index: 7
Vehicle 15 is crossing the bridge in direction 1
Vehicle 9 has exited the bridge in direction 1. Departure index: 8
Vehicle 7 is crossing the bridge in direction 1
Vehicle 8 has exited the bridge in direction 1. Departure index: 9
Vehicle 16 is crossing the bridge in direction 1
Vehicle 15 has exited the bridge in direction 1. Departure index: 10
Vehicle 11 is crossing the bridge in direction 1
Vehicle 7 has exited the bridge in direction 1. Departure index: 11
Vehicle 16 has exited the bridge in direction 1. Departure index: 12
Vehicle 11 is crossing the bridge in direction 1
Vehicle 11 has exited the bridge in direction 1. Departure index: 13
Vehicle 17 is crossing the bridge in direction 0
Vehicle 14 is crossing the bridge in direction 0
Vehicle 11 has exited the bridge in direction 1. Departure index: 14
Vehicle 13 is crossing the bridge in direction 0
Vehicle 17 has exited the bridge in direction 0. Departure index: 15
Vehicle 13 has exited the bridge in direction 0. Departure index: 16
```





```
Vehicle 13 has exited the bridge in direction 0. Departure index: 16
Vehicle 19 is crossing the bridge in direction 0
Vehicle 14 has exited the bridge in direction 0. Departure index: 17
Vehicle 6 is crossing the bridge in direction 0
Vehicle 18 is crossing the bridge in direction 0
Vehicle 19 has exited the bridge in direction 0. Departure index: 18
Vehicle 6 has exited the bridge in direction 0. Departure index: 19
Vehicle 18 has exited the bridge in direction 0. Departure index: 20
```

3)

Same experiment with 20 vehicles arriving all simultaneously. In this case, the bridge is initially crossed by the vehicles whose direction match the first vehicle's direction.

```
Please choose the vehicle arrival schedule
            Enter 1 for: 5 : DELAY(10) : 5 : DELAY(10) : 5 : DELAY(10) : 5
            Enter 2 for: 10 : DELAY(10) : 10
            Enter 3 for: 20
            choice:3
Creation of the Vehicles
Vehicle 0 has arrived to the bridge
Vehicle 0 is crossing the bridge in direction 0
Vehicle 1 has arrived to the bridge
Vehicle 1 is crossing the bridge in direction 0
Vehicle 2 has arrived to the bridge
Vehicle 3 has arrived to the bridge
Vehicle 3 is crossing the bridge in direction 0
Vehicle 4 has arrived to the bridge
Vehicle 5 has arrived to the bridge
Vehicle 6 has arrived to the bridge
Vehicle 7 has arrived to the bridge
Vehicle 8 has arrived to the bridge
Vehicle 9 has arrived to the bridge
Vehicle 10 has arrived to the bridge
Vehicle 11 has arrived to the bridge
Vehicle 12 has arrived to the bridge
Vehicle 13 has arrived to the bridge
Vehicle 14 has arrived to the bridge
Vehicle 15 has arrived to the bridge
Vehicle 16 has arrived to the bridge
Vehicle 17 has arrived to the bridge
Vehicle 18 has arrived to the bridge
Vehicle 19 has arrived to the bridge
Vehicle 10 is crossing the bridge in direction 0
Vehicle 1 has exited the bridge in direction 0. Departure index: 1
Vehicle 0 has exited the bridge in direction 0. Departure index: 2
Vehicle 18 is crossing the bridge in direction 0
Vehicle 3 has exited the bridge in direction 0. Departure index: 3
Vehicle 6 is crossing the bridge in direction 0
Vehicle 10 has exited the bridge in direction 0. Departure index: 4
Vehicle 14 is crossing the bridge in direction 0
Vehicle 18 has exited the bridge in direction 0. Departure index: 5
Vehicle 17 is crossing the bridge in direction 0
Vehicle 6 has exited the bridge in direction 0. Departure index: 6
Vehicle 13 is crossing the bridge in direction 0
Vehicle 14 has exited the bridge in direction 0. Departure index: 7
Vehicle 19 is crossing the bridge in direction 0
Vehicle 17 has exited the bridge in direction 0. Departure index: 8
Vehicle 5 is crossing the bridge in direction 0
Vehicle 13 has exited the bridge in direction 0. Departure index: 9
Vehicle 19 has exited the bridge in direction 0. Departure index: 10
Vehicle 11 is crossing the bridge in direction 1
Vehicle 5 has exited the bridge in direction 0. Departure index: 11
Vehicle 9 is crossing the bridge in direction 1
Vehicle 12 is crossing the bridge in direction 1
Vehicle 12 has exited the bridge in direction 1. Departure index: 12
Vehicle 2 is crossing the bridge in direction 1
Vehicle 4 is crossing the bridge in direction 1
Vehicle 11 has exited the bridge in direction 1. Departure index: 12
Vehicle 8 is crossing the bridge in direction 1
Vehicle 9 has exited the bridge in direction 1. Departure index: 12
Vehicle 2 has exited the bridge in direction 1. Departure index: 15
Vehicle 15 is crossing the bridge in direction 1
```

```
Vehicle 15 is crossing the bridge in direction 1
Vehicle 4 has exited the bridge in direction 1. Departure index: 16
Vehicle 16 is crossing the bridge in direction 1
Vehicle 8 has exited the bridge in direction 1. Departure index: 17
Vehicle 7 is crossing the bridge in direction 1
Vehicle 15 has exited the bridge in direction 1. Departure index: 18
Vehicle 16 has exited the bridge in direction 1. Departure index: 19
Vehicle 7 has exited the bridge in direction 1. Departure index: 20
```

Conclusion and Known issues:

As we implemented the semaphore concept in our project using a while loop instead of the standard queue implementation. It is possible for vehicles waiting for their turn to cross out of order than the order they arrived at.