CSE 344
SYSTEM PROGRAMMING

HW 3 Report

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INTRODUCTION

This project implements a parking lot simulation using pthreads, semaphores, and shared memory. The main objective is to manage parking spaces for two types of vehicles: automobiles and pickups. This simulation ensures thread-safe operations using synchronization primitives to prevent race conditions and ensure proper coordination between threads.

To compile program in shell: $> make
To run program correctly: $> ./parking
To clean unnecessary files: $> make clean

USED STRUCTURES & METHODS

ParkingLot Structure: This structure maintains the count of available parking spaces for automobiles and pickups. It is shared among all threads to provide a consistent view of the parking lot state.

Semaphores

newPickup and newAutomobile: These semaphores signal when a new pickup or automobile is ready to be parked.

inChargeforPickup and inChargeforAutomobile: These semaphores ensure that only one car attendant can park a vehicle at a time.

pickupCounterControl and automobileCounterControl: These semaphores protect access to the counters of available parking spaces, preventing race conditions when these values are read or modified.

Threads

Car Owners: These threads attempt to park their vehicles in the lot. They decrement the available parking spaces and signal car attendants when they find a spot.

Car Attendants: These threads handle the actual parking process, incrementing the available spaces once a vehicle is parked.

Design of Thread Operations

Car Owners

The function waits on the automobileCounterControl semaphore to gain exclusive access to the shared resource, ensuring no other thread can modify the automobile parking counter simultaneously. Then it checks if there is at least one free parking space for automobiles. If a space is available, the count of free automobile spaces is decremented. The automobileCounterControl semaphore is released, allowing other threads to access the automobile parking counter.

The newAutomobile semaphore is posted to signal a car attendant thread that an automobile is ready to be parked. The function waits on the inChargeforAutomobile semaphore for the car attendant to signal that the automobile has been parked.

If no space is available, the automobileCounterControl semaphore is released without decrementing the counter.

Car Attendants

The function waits on the pickupCounterControl semaphore to gain exclusive access to the shared resource, ensuring no other thread can modify the pickup parking counter simultaneously. The function checks if there is at least one free parking space for pickups. If a space is available, the count of free pickup spaces is decremented. The pickupCounterControl semaphore is released, allowing other threads to access the pickup parking counter.

The newPickup semaphore is posted to signal a car attendant thread that a pickup is ready to be parked. The function waits on the inChargeforPickup semaphore for the car attendant to signal that the pickup has been parked.

If no space is available, the pickupCounterControl semaphore is released without decrementing the counter.

PARKING SIMULATION FOR TEST

The parkingSimulation function is responsible for organizing the entire parking lot simulation. It creates and manages threads for car owners and car attendants.

An array is declared to hold the thread identifiers for car owner and car attendant threads. The array size is NUM_VEHICLES + 2 to accommodate all car owner threads plus two car attendant threads.

Car Attendant Threads: Two threads are created for car attendants: one to handle automobiles and one to handle pickups. These threads are responsible for managing the actual parking process once a vehicle arrives. The car attendant threads are given an argument specifying the type of vehicle they will handle (either "automobile" or "pickup").

Car Owner Threads: A loop runs NUM_VEHICLES times to create threads for each car owner. Each car owner is assigned a dynamically allocated integer that indicates the vehicle type (0 for automobile, 1 for pickup). The type of vehicle for each car owner is determined randomly to simulate real-world conditions where different types of vehicles arrive at random.

Joining Car Owner Threads: The main thread waits for all car owner threads to complete their execution. This ensures that the simulation does not proceed to the next steps until all car owner threads have finished.

Stop Flag: A stop flag is set to signal the car attendant threads to stop their operations once they complete their current tasks.

Semaphore Post: Semaphores are posted to unblock any car attendant threads that might be waiting, allowing them to check the stop flag and exit gracefully.

Joining Car Attendant Threads: The main thread waits for the car attendant threads to complete their execution. This ensures that the simulation is properly concluded, and all resources are cleaned up before the program terminates.

Sleep in parkingSimulation: A small random sleep interval is used between the creation of car owner threads to simulate the random arrival times of vehicles at the parking lot. The delay is randomized to ensure that vehicle arrivals are not uniform and making it more realistic.

Sleep in carAttendant: Within the car attendant thread, a random delay is used between handling each vehicle to simulate the time it takes for an attendant to park a vehicle and prepare for the next one. This randomness prevents the threads from continuously looping without any break, which helps in simulating a more realistic scenario where attendants have varying times to complete their tasks.

TESTS

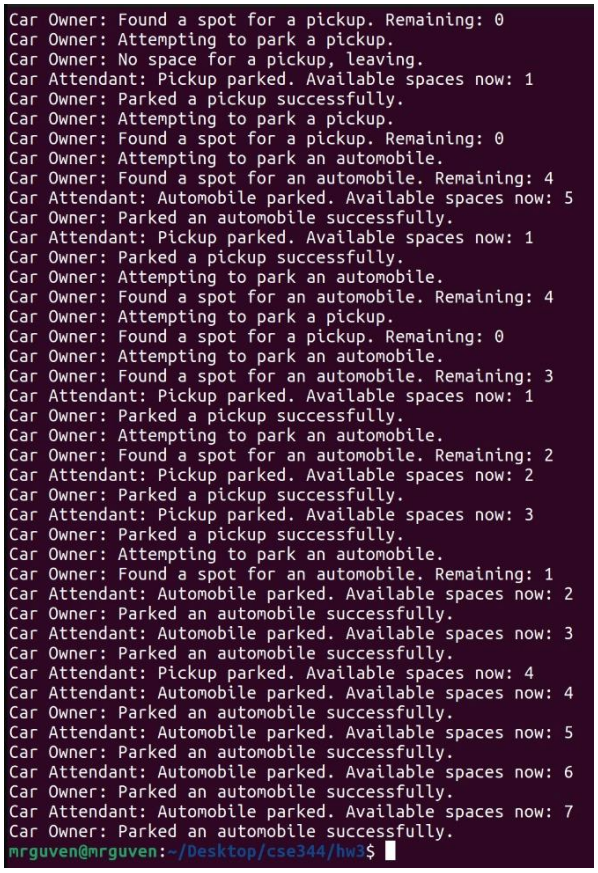
I test the program with 3 different car owner numbers, 10, 20 and 50. Execution is given below.

10 Car Owners

```
mrguven@mrguven:~/Desktop/cse344/hw3$ make
gcc -Wall -std=gnu99 parking.c -o parking -lpthread -lrt
mrguven@mrguven:~/Desktop/cse344/hw3$ ./parking
Car Owner: Attempting to park a pickup.
Car Owner: Found a spot for a pickup. Remaining: 3
Car Owner: Parked a pickup successfully.
Car Attendant: Pickup parked. Available spaces now: 4
Car Owner: Attempting to park a pickup.
Car Owner: Found a spot for a pickup. Remaining: 3
Car Owner: Parked a pickup successfully.
Car Owner: Attempting to park a pickup.
Car Owner: Found a spot for a pickup. Remaining: 2
Car Owner: Attempting to park an automobile.
Car Owner: Found a spot for an automobile. Remaining: 7
Car Owner: Parked an automobile successfully.
Car Attendant: Automobile parked. Available spaces now: 8
Car Owner: Attempting to park an automobile.
Car Owner: Found a spot for an automobile. Remaining: 7
Car Owner: Parked an automobile successfully.
Car Attendant: Automobile parked. Available spaces now: 8
Car Owner: Attempting to park a pickup.
Car Owner: Found a spot for a pickup. Remaining: 1
Car Owner: Attempting to park an automobile.
Car Owner: Found a spot for an automobile. Remaining: 7
Car Owner: Parked an automobile successfully.
Car Attendant: Automobile parked. Available spaces now: 8
Car Owner: Attempting to park a pickup.
Car Owner: Found a spot for a pickup. Remaining: 0
Car Attendant: Pickup parked. Available spaces now: 1
Car Owner: Parked a pickup successfully.
Car Attendant: Pickup parked. Available spaces now: 2
Car Owner: Parked a pickup successfully.
Car Owner: Attempting to park a pickup.
Car Owner: Found a spot for a pickup. Remaining: 1
Car Owner: Attempting to park a pickup.
Car Owner: Found a spot for a pickup. Remaining: 0
Car Attendant: Pickup parked. Available spaces now: 1
Car Owner: Parked a pickup successfully.
Car Attendant: Pickup parked. Available spaces now: 2
Car Owner: Parked a pickup successfully.
Car Attendant: Pickup parked. Available spaces now: 3
Car Owner: Parked a pickup successfully.
mrguven@mrguven:~/Desktop/cse344/hw3$
```

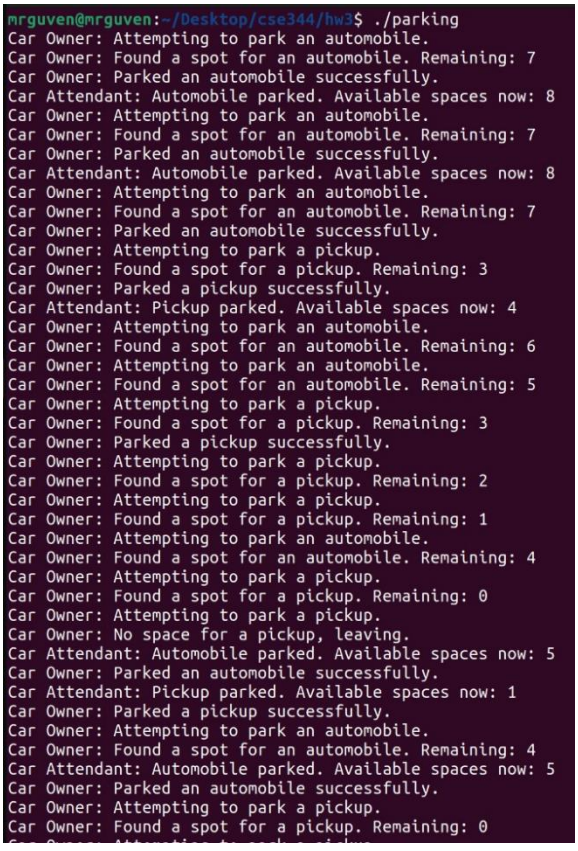
20 Car Owners

```
mrguven@mrguven:~/Desktop/cse344/hw3$ make
gcc -Wall -std=gnu99 parking.c -o parking -lpthread -lrt
mrguven@mrguven:~/Desktop/cse344/hw3$ ./parking
Car Owner: Attempting to park a pickup.
Car Owner: Found a spot for a pickup. Remaining: 3
Car Owner: Parked a pickup successfully.
Car Attendant: Pickup parked. Available spaces now: 4
Car Owner: Attempting to park a pickup.
Car Owner: Found a spot for a pickup. Remaining: 3
Car Owner: Parked a pickup successfully.
Car Owner: Attempting to park an automobile.
Car Owner: Found a spot for an automobile. Remaining: 7
Car Owner: Parked an automobile successfully.
Car Attendant: Automobile parked. Available spaces now: 8
Car Owner: Attempting to park a pickup.
Car Owner: Found a spot for a pickup. Remaining: 2
Car Owner: Attempting to park a pickup.
Car Owner: Found a spot for a pickup. Remaining: 1
Car Owner: Attempting to park a pickup.
Car Owner: Found a spot for a pickup. Remaining: 0
Car Owner: Attempting to park an automobile.
Car Owner: Found a spot for an automobile. Remaining: 7
Car Owner: Parked an automobile successfully.
Car Attendant: Automobile parked. Available spaces now: 8
Car Attendant: Pickup parked. Available spaces now: 1
Car Owner: Parked a pickup successfully.
Car Owner: Attempting to park a pickup.
Car Owner: Found a spot for a pickup. Remaining: 0
Car Owner: Attempting to park an automobile.
Car Owner: Found a spot for an automobile. Remaining: 7
Car Owner: Parked an automobile successfully.
Car Owner: Attempting to park an automobile.
Car Owner: Found a spot for an automobile. Remaining: 6
Car Attendant: Pickup parked. Available spaces now: 1
Car Owner: Parked a pickup successfully.
Car Owner: Attempting to park an automobile.
Car Owner: Found a spot for an automobile. Remaining: 5
Car Owner: Attempting to park a pickup.
Car Owner: Found a spot for a pickup. Remaining: 0
Car Owner: Attempting to park a pickup.
Car Owner: No space for a pickup, leaving.
Car Attendant: Pickup parked. Available spaces now: 1
Car Owner: Parked a pickup successfully.
```



```
Car Owner: Found a spot for a pickup. Remaining: 0
Car Owner: Attempting to park a pickup.
Car Owner: No space for a pickup, leaving.
Car Attendant: Pickup parked. Available spaces now: 1
Car Owner: Parked a pickup successfully.
Car Owner: Attempting to park a pickup.
Car Owner: Found a spot for a pickup. Remaining: 0
Car Owner: Attempting to park an automobile.
Car Owner: Found a spot for an automobile. Remaining: 4
Car Attendant: Automobile parked. Available spaces now: 5
Car Owner: Parked an automobile successfully.
Car Attendant: Pickup parked. Available spaces now: 1
Car Owner: Parked a pickup successfully.
Car Owner: Attempting to park an automobile.
Car Owner: Found a spot for an automobile. Remaining: 4
Car Owner: Attempting to park a pickup.
Car Owner: Found a spot for a pickup. Remaining: 0
Car Owner: Attempting to park an automobile.
Car Owner: Found a spot for an automobile. Remaining: 3
Car Attendant: Pickup parked. Available spaces now: 1
Car Owner: Parked a pickup successfully.
Car Owner: Attempting to park an automobile.
Car Owner: Found a spot for an automobile. Remaining: 2
Car Attendant: Pickup parked. Available spaces now: 2
Car Owner: Parked a pickup successfully.
Car Attendant: Pickup parked. Available spaces now: 3
Car Owner: Parked a pickup successfully.
Car Owner: Attempting to park an automobile.
Car Owner: Found a spot for an automobile. Remaining: 1
Car Attendant: Automobile parked. Available spaces now: 2
Car Owner: Parked an automobile successfully.
Car Attendant: Automobile parked. Available spaces now: 3
Car Owner: Parked an automobile successfully.
Car Attendant: Pickup parked. Available spaces now: 4
Car Attendant: Automobile parked. Available spaces now: 4
Car Owner: Parked an automobile successfully.
Car Attendant: Automobile parked. Available spaces now: 5
Car Owner: Parked an automobile successfully.
Car Attendant: Automobile parked. Available spaces now: 6
Car Owner: Parked an automobile successfully.
Car Attendant: Automobile parked. Available spaces now: 7
Car Owner: Parked an automobile successfully.
mrguven@mrguven:~/Desktop/cse344/hw3$
```

50 Car Owners



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mrguven@mrguven:~/Desktop/cse344/hw3$ ./parking
Car Owner: Attempting to park an automobile.
Car Owner: Found a spot for an automobile. Remaining: 7
Car Owner: Parked an automobile successfully.
Car Attendant: Automobile parked. Available spaces now: 8
Car Owner: Attempting to park an automobile.
Car Owner: Found a spot for an automobile. Remaining: 7
Car Owner: Parked an automobile successfully.
Car Attendant: Automobile parked. Available spaces now: 8
Car Owner: Attempting to park an automobile.
Car Owner: Found a spot for an automobile. Remaining: 7
Car Owner: Parked an automobile successfully.
Car Owner: Attempting to park a pickup.
Car Owner: Found a spot for a pickup. Remaining: 3
Car Owner: Parked a pickup successfully.
Car Attendant: Pickup parked. Available spaces now: 4
Car Owner: Attempting to park an automobile.
Car Owner: Found a spot for an automobile. Remaining: 6
Car Owner: Attempting to park an automobile.
Car Owner: Found a spot for an automobile. Remaining: 5
Car Owner: Attempting to park a pickup.
Car Owner: Found a spot for a pickup. Remaining: 3
Car Owner: Parked a pickup successfully.
Car Owner: Attempting to park a pickup.
Car Owner: Found a spot for a pickup. Remaining: 2
Car Owner: Attempting to park a pickup.
Car Owner: Found a spot for a pickup. Remaining: 1
Car Owner: Attempting to park an automobile.
Car Owner: Found a spot for an automobile. Remaining: 4
Car Owner: Attempting to park a pickup.
Car Owner: Found a spot for a pickup. Remaining: 0
Car Owner: Attempting to park a pickup.
Car Owner: No space for a pickup, leaving.
Car Attendant: Automobile parked. Available spaces now: 5
Car Owner: Parked an automobile successfully.
Car Attendant: Pickup parked. Available spaces now: 1
Car Owner: Parked a pickup successfully.
Car Owner: Attempting to park an automobile.
Car Owner: Found a spot for an automobile. Remaining: 4
Car Attendant: Automobile parked. Available spaces now: 5
Car Owner: Parked an automobile successfully.
Car Owner: Attempting to park a pickup.
Car Owner: Found a spot for a pickup. Remaining: 0
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Car Owner: Attempting to park a pickup.
Car Owner: Found a spot for a pickup. Remaining: 0
Car Owner: Attempting to park a pickup.
Car Owner: No space for a pickup, leaving.
Car Owner: Attempting to park a pickup.
Car Owner: No space for a pickup, leaving.
Car Owner: Attempting to park an automobile.
Car Owner: Found a spot for an automobile. Remaining: 4
Car Attendant: Pickup parked. Available spaces now: 1
Car Owner: Parked a pickup successfully.
Car Owner: Attempting to park a pickup.
Car Owner: Found a spot for a pickup. Remaining: 0
Car Owner: Attempting to park a pickup.
Car Owner: No space for a pickup, leaving.
Car Owner: Attempting to park an automobile.
Car Owner: Found a spot for an automobile. Remaining: 3
Car Attendant: Pickup parked. Available spaces now: 1
Car Owner: Parked a pickup successfully.
Car Owner: Attempting to park a pickup.
Car Owner: Found a spot for a pickup. Remaining: 0
Car Owner: Attempting to park an automobile.
Car Owner: Found a spot for an automobile. Remaining: 2
Car Owner: Attempting to park a pickup.
Car Owner: No space for a pickup, leaving.
Car Owner: Attempting to park an automobile.
Car Owner: Found a spot for an automobile. Remaining: 1
Car Attendant: Automobile parked. Available spaces now: 2
Car Owner: Parked an automobile successfully.
Car Attendant: Pickup parked. Available spaces now: 1
Car Owner: Parked a pickup successfully.
Car Owner: Attempting to park a pickup.
Car Owner: Found a spot for a pickup. Remaining: 0
Car Owner: Attempting to park a pickup.
Car Owner: No space for a pickup, leaving.
Car Owner: Attempting to park an automobile.
Car Owner: Found a spot for an automobile. Remaining: 1
Car Owner: Attempting to park a pickup.
Car Owner: No space for a pickup, leaving.
Car Owner: Attempting to park an automobile.
Car Owner: Found a spot for an automobile. Remaining: 0
Car Owner: Attempting to park a pickup.
Car Owner: No space for a pickup, leaving.
Car Attendant: Pickup parked. Available spaces now: 1
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Car Owner: No space for a pickup, leaving.
Car Attendant: Pickup parked. Available spaces now: 1
Car Owner: Parked a pickup successfully.
Car Attendant: Automobile parked. Available spaces now: 1
Car Owner: Parked an automobile successfully.
Car Owner: Attempting to park an automobile.
Car Owner: Found a spot for an automobile. Remaining: 0
Car Owner: Attempting to park a pickup.
Car Owner: Found a spot for a pickup. Remaining: 0
Car Owner: Attempting to park a pickup.
Car Owner: No space for a pickup, leaving.
Car Owner: Attempting to park an automobile.
Car Owner: No space for an automobile, leaving.
Car Attendant: Automobile parked. Available spaces now: 1
Car Owner: Parked an automobile successfully.
Car Owner: Attempting to park a pickup.
Car Owner: No space for a pickup, leaving.
Car Owner: Attempting to park a pickup.
Car Owner: No space for a pickup, leaving.
Car Attendant: Pickup parked. Available spaces now: 1
Car Owner: Parked a pickup successfully.
Car Owner: Attempting to park a pickup.
Car Owner: Found a spot for a pickup. Remaining: 0
Car Owner: Attempting to park an automobile.
Car Owner: Found a spot for an automobile. Remaining: 0
Car Attendant: Automobile parked. Available spaces now: 1
Car Owner: Parked an automobile successfully.
Car Owner: Attempting to park an automobile.
Car Owner: Found a spot for an automobile. Remaining: 0
Car Attendant: Automobile parked. Available spaces now: 1
Car Owner: Parked an automobile successfully.
Car Owner: Attempting to park a pickup.
Car Owner: No space for a pickup, leaving.
Car Attendant: Pickup parked. Available spaces now: 1
Car Owner: Parked a pickup successfully.
Car Attendant: Automobile parked. Available spaces now: 2
Car Owner: Parked an automobile successfully.
Car Owner: Attempting to park an automobile.
Car Owner: Found a spot for an automobile. Remaining: 1
Car Owner: Attempting to park a pickup.
Car Owner: Found a spot for a pickup. Remaining: 0
Car Owner: Attempting to park a pickup.
Car Owner: No space for a pickup, leaving.
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Car Owner: Attempting to park a pickup.
Car Owner: Found a spot for a pickup. Remaining: 0
Car Owner: Attempting to park a pickup.
Car Owner: No space for a pickup, leaving.
Car Owner: Attempting to park a pickup.
Car Owner: No space for a pickup, leaving.
Car Owner: Attempting to park a pickup.
Car Owner: No space for a pickup, leaving.
Car Owner: Attempting to park a pickup.
Car Owner: No space for a pickup, leaving.
Car Attendant: Pickup parked. Available spaces now: 1
Car Owner: Parked a pickup successfully.
Car Owner: Attempting to park an automobile.
Car Owner: Found a spot for an automobile. Remaining: 0
Car Owner: Attempting to park a pickup.
Car Owner: Found a spot for a pickup. Remaining: 0
Car Owner: Attempting to park an automobile.
Car Owner: No space for an automobile, leaving.
Car Attendant: Pickup parked. Available spaces now: 1
Car Owner: Parked a pickup successfully.
Car Owner: Attempting to park a pickup.
Car Owner: Found a spot for a pickup. Remaining: 0
Car Attendant: Automobile parked. Available spaces now: 1
Car Owner: Parked an automobile successfully.
Car Attendant: Pickup parked. Available spaces now: 1
Car Owner: Parked a pickup successfully.
Car Attendant: Automobile parked. Available spaces now: 2
Car Owner: Parked an automobile successfully.
Car Attendant: Automobile parked. Available spaces now: 3
Car Owner: Parked an automobile successfully.
Car Attendant: Pickup parked. Available spaces now: 2
Car Owner: Parked a pickup successfully.
Car Attendant: Automobile parked. Available spaces now: 4
Car Owner: Parked an automobile successfully.
Car Attendant: Automobile parked. Available spaces now: 5
Car Owner: Parked an automobile successfully.
Car Attendant: Automobile parked. Available spaces now: 6
Car Owner: Parked an automobile successfully.
Car Attendant: Automobile parked. Available spaces now: 7
Car Owner: Parked an automobile successfully.
Car Attendant: Pickup parked. Available spaces now: 3
Car Owner: Parked a pickup successfully.
mrguven@mrguven:~/Desktop/cse344/hw3$
```