CSE 344

Homework #3 Report

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How to compile and run:

```
berry@DESKTOP-O92GAB6:/mnt/c/Users/lafci/Desktop/GTU/4. sınıf/4. sinif 2. donem/System Programming/HW3$ make
gcc -Wall -Wextra -Werror -c hw3.c -o hw3.o
gcc -Wall -Wextra -Werror -o hw3 hw3.o
berry@DESKTOP-O92GAB6:/mnt/c/Users/lafci/Desktop/GTU/4. sınıf/4. sinif 2. donem/System Programming/HW3$ ./hw3
Automobile owner parks its vehicle in temporary lot. Free places for automobiles: 7
```

Clean:

```
berry@DESKTOP-O92GAB6:/mnt/c/Users/lafci/Desktop/GTU/4. sınıf/4. sinif 2. donem/System Programming/HW3$ make clean
rm -f hw3 hw3.o
berry@DESKTOP-O92GAB6:/mnt/c/Users/lafci/Desktop/GTU/4. sınıf/4. sinif 2. donem/System Programming/HW3$
```

Logic of the code:

Variables and Semaphores

- **sem_t newPickup, inChargeforPickup, newAutomobile, inChargeforAutomobile**: Semaphores used to synchronize the operations between car owners and the attendant.
- **int mFree_automobile = 8**: Initial number of free parking spaces for automobiles.
- **int mFree_pickup = 4**: Initial number of free parking spaces for pickups.
- **pthread_t carOwnerThread, carAttendantThread**: Thread identifiers for car owner and car attendant threads.

Signal Handling

A signal handler function, **sigint_handler**, is defined to clean up resources smoothly when a SIGINT (Ctrl+C) signal is received. This function cancels the threads and destroys the semaphores before exiting.

```c
void sigint_handler() {
    printf("\nSIGINT received. Cleaning threads.\n");
    pthread_cancel(carAttendantThread);
    pthread_cancel(carOwnerThread);
    sem_destroy(&newPickup);
    sem_destroy(&inChargeforPickup);
    sem_destroy(&newAutomobile);
    sem_destroy(&inChargeforAutomobile);
    exit(0);
}
```

Car Owner Thread Function

In my code, I decided to make an infinite amount of car owners to keep the code running continuously. So this thread works in while(1) loop.

1. It generates a random vehicle type (automobile or pickup) with rand() function.

```
while (1) {
int vehicleType = rand() % 2; //
```

2. Depending on the vehicle type, it checks if there are available parking spaces.
3. If a space is available:
    - It decreases the number of free spaces.
    - It tells the attendant that “You can take this vehicle now” by posting to the relevant semaphore (**newPickup** or **newAutomobile**).
4. If no space is available, it prints a message indicating the vehicle owner leaves without parking.
5. The thread sleeps for 1 second before the next vehicle arrives.

Car Attendant Thread Function

1. It continuously waits for to be able to enter critical region indicating new arrivals of pickups and automobiles.
2. When it enters critical region:
    - It increases the count of free spaces for the respective vehicle type.
3. It repeats this process for both pickups and automobiles.

Main Function

1. It seeds the random number generator.
2. It initializes the semaphores with initial values.
3. It sets up the signal handler for SIGINT.

4. It creates the car owner and car attendant threads using **pthread_create**.

```
// Create threads
pthread_create(&carAttendantThread, NULL, carAttendant, NULL);
pthread_create(&carOwnerThread, NULL, carOwner, NULL);
```

5. It waits for the threads to finish using **pthread_join**.

```
// Wait for threads to finish
pthread_join(carAttendantThread, NULL);
pthread_join(carOwnerThread, NULL);
```

Use of Semaphores

Semaphores: inChargeforPickup and inChargeforAutomobile are binary semaphores and ensure mutual exclusion.

- Both semaphores are initialized to 1, indicating that the critical regions are available.

```
sem_init(&inChargeforPickup, 0, 1);
sem_init(&inChargeforAutomobile, 0, 1);
```

- **Car Owner Thread**:
    - When a car owner thread wants to park a vehicle, it calls **sem_wait(&inChargeforPickup)** or **sem_wait(&inChargeforAutomobile)** before entering the critical region.
    - This decreases the semaphore value to 0 and enters the critical region.
    - While the semaphore is 0, no other thread can enter the critical region that modifies the same count which are **mFree_pickup** or **mFree_automobile**. Because they are global variables, if we don't use semaphore, we can't prevent the same time changes **(race conditions).**
    - After modifying the count, the car owner thread calls **sem_post(&inChargeforPickup)** or **sem_post(&inChargeforAutomobile)**, increasing the semaphore value back to 1, exits from the critical region.
- **Car Attendant Thread**:

- When the car attendant thread takes a vehicle to park, it also calls **sem_wait(&inChargeforPickup)** or **sem_wait(&inChargeforAutomobile)** to enter the critical region.
- The same logic ensures that the attendant thread cannot enter the critical region if a car owner thread is already modifying the count.
- After updating the count, the car attendant thread calls **sem_post(&inChargeforPickup)** or **sem_post(&inChargeforAutomobile)**, unlocking the critical region.

Semaphores: newPickup and newAutomobile are counting semaphores.

- Both semaphores are initialized to 0, indicating no new vehicles have arrived yet.

```
// Initialize semaphores
sem_init(&newPickup, 0, 0);
sem_init(&newAutomobile, 0, 0);
```

- **Car Owner Thread**:
  - When a car owner parks a vehicle, it calls **sem_post(&newPickup)** or **sem_post(&newAutomobile)**, increasing the semaphore value by 1.
  - This tells the car attendant thread that a new vehicle is waiting to be processed so that attendant can take the vehicle now.
- **Car Attendant Thread**:
  - If the semaphore value is 0, the attendant thread will block and wait until a car owner posts to the semaphore (until new vehicles come).
  - Once a car owner posts to the semaphore, the attendant thread is unblocked, allowing it to process the vehicle.

Thus, in this code carOwner acts as the producer and carAttendant acts as the consumer.

Use of Threads

- The **carOwnerThread** continuously generates vehicle arrivals, attempts to park them, and informs the attendant with semaphores.
- The **carAttendantThread** continuously waits from the car owner thread and parks the vehicles, freeing up spaces.

Example runs:

```
berry@DESKTOP-O92GAB6:/mnt/c/Users/lafci/Desktop/GTU/4. sınıf/4. sinif 2. donem/System Programming/HW3$ ./hw3
Automobile owner parks its vehicle in temporary lot. Free places for automobiles: 7
Pickup owner parks its vehicle in temporary lot. Free places for pickups: 3
Attendant parked pickup. Free places for pickups: 4
Attendant parked automobile. Free places for automobiles: 8
Automobile owner parks its vehicle in temporary lot. Free places for automobiles: 7
Automobile owner parks its vehicle in temporary lot. Free places for automobiles: 6
Pickup owner parks its vehicle in temporary lot. Free places for pickups: 3
Attendant parked pickup. Free places for pickups: 4
Attendant parked automobile. Free places for automobiles: 7
Pickup owner parks its vehicle in temporary lot. Free places for pickups: 3
Attendant parked pickup. Free places for pickups: 4
Attendant parked automobile. Free places for automobiles: 8
Automobile owner parks its vehicle in temporary lot. Free places for automobiles: 7
Pickup owner parks its vehicle in temporary lot. Free places for pickups: 3
Attendant parked pickup. Free places for pickups: 4
Attendant parked automobile. Free places for automobiles: 8
Automobile owner parks its vehicle in temporary lot. Free places for automobiles: 7
Automobile owner parks its vehicle in temporary lot. Free places for automobiles: 6
Pickup owner parks its vehicle in temporary lot. Free places for pickups: 3
Attendant parked pickup. Free places for pickups: 4
Attendant parked automobile. Free places for automobiles: 7
Automobile owner parks its vehicle in temporary lot. Free places for automobiles: 6
Automobile owner parks its vehicle in temporary lot. Free places for automobiles: 5
Pickup owner parks its vehicle in temporary lot. Free places for pickups: 3
Attendant parked pickup. Free places for pickups: 4
Attendant parked automobile. Free places for automobiles: 6
Pickup owner parks its vehicle in temporary lot. Free places for pickups: 3
Attendant parked pickup. Free places for pickups: 4
Attendant parked automobile. Free places for automobiles: 7
Automobile owner parks its vehicle in temporary lot. Free places for automobiles: 6
Pickup owner parks its vehicle in temporary lot. Free places for pickups: 3
Attendant parked pickup. Free places for pickups: 4
Attendant parked automobile. Free places for automobiles: 7
Pickup owner parks its vehicle in temporary lot. Free places for pickups: 3
Attendant parked pickup. Free places for pickups: 4
Attendant parked automobile. Free places for automobiles: 8
Pickup owner parks its vehicle in temporary lot. Free places for pickups: 3
Attendant parked pickup. Free places for pickups: 4
^C
SIGINT received. Cleaning threads.
berry@DESKTOP-O92GAB6:/mnt/c/Users/lafci/Desktop/GTU/4. sınıf/4. sinif 2. donem/System Programming/HW3$ make clean
```

```
berry@DESKTOP-O92GAB6:/mnt/c/Users/lafci/Desktop/GTU/4. sınıf/4. sinif 2. donem/System Programming/HW3$ ./hw3
Automobile owner parks its vehicle in temporary lot. Free places for automobiles: 7
Pickup owner parks its vehicle in temporary lot. Free places for pickups: 3
Attendant parked pickup. Free places for pickups: 4
Attendant parked automobile. Free places for automobiles: 8
Pickup owner parks its vehicle in temporary lot. Free places for pickups: 3
Attendant parked pickup. Free places for pickups: 4
Pickup owner parks its vehicle in temporary lot. Free places for pickups: 3
Pickup owner parks its vehicle in temporary lot. Free places for pickups: 2
Automobile owner parks its vehicle in temporary lot. Free places for automobiles: 7
Attendant parked automobile. Free places for automobiles: 8
Attendant parked pickup. Free places for pickups: 3
Pickup owner parks its vehicle in temporary lot. Free places for pickups: 2
Automobile owner parks its vehicle in temporary lot. Free places for automobiles: 7
Attendant parked automobile. Free places for automobiles: 8
Attendant parked pickup. Free places for pickups: 3
Automobile owner parks its vehicle in temporary lot. Free places for automobiles: 7
Attendant parked automobile. Free places for automobiles: 8
Attendant parked pickup. Free places for pickups: 4
Pickup owner parks its vehicle in temporary lot. Free places for pickups: 3
Automobile owner parks its vehicle in temporary lot. Free places for automobiles: 7
Attendant parked automobile. Free places for automobiles: 8
Attendant parked pickup. Free places for pickups: 4
Automobile owner parks its vehicle in temporary lot. Free places for automobiles: 7
Attendant parked automobile. Free places for automobiles: 8
Pickup owner parks its vehicle in temporary lot. Free places for pickups: 3
Attendant parked pickup. Free places for pickups: 4
Automobile owner parks its vehicle in temporary lot. Free places for automobiles: 7
Attendant parked automobile. Free places for automobiles: 8
Pickup owner parks its vehicle in temporary lot. Free places for pickups: 3
Attendant parked pickup. Free places for pickups: 4
Pickup owner parks its vehicle in temporary lot. Free places for pickups: 3
Pickup owner parks its vehicle in temporary lot. Free places for pickups: 2
Automobile owner parks its vehicle in temporary lot. Free places for automobiles: 7
Attendant parked automobile. Free places for automobiles: 8
Attendant parked pickup. Free places for pickups: 3
Automobile owner parks its vehicle in temporary lot. Free places for automobiles: 7
Attendant parked automobile. Free places for automobiles: 8
Attendant parked pickup. Free places for pickups: 4
Pickup owner parks its vehicle in temporary lot. Free places for pickups: 3
Pickup owner parks its vehicle in temporary lot. Free places for pickups: 2
Pickup owner parks its vehicle in temporary lot. Free places for pickups: 1
Pickup owner parks its vehicle in temporary lot. Free places for pickups: 0
No space left for pickups in temporary lot. Pickup owner leaves.
No space left for pickups in temporary lot. Pickup owner leaves.
Automobile owner parks its vehicle in temporary lot. Free places for automobiles: 7
Attendant parked automobile. Free places for automobiles: 8
Attendant parked pickup. Free places for pickups: 1
```

```
berry@DESKTOP-O92GAB6:/mnt/c/Users/lafci/Desktop/GTU/4. sınıf/4. sinif 2. donem/System Programming/HW3$ ./hw3
Automobile owner parks its vehicle in temporary lot. Free places for automobiles: 7
Automobile owner parks its vehicle in temporary lot. Free places for automobiles: 6
Automobile owner parks its vehicle in temporary lot. Free places for automobiles: 5
Pickup owner parks its vehicle in temporary lot. Free places for pickups: 3
Attendant parked pickup. Free places for pickups: 4
Attendant parked automobile. Free places for automobiles: 6
Pickup owner parks its vehicle in temporary lot. Free places for pickups: 3
Attendant parked pickup. Free places for pickups: 4
Attendant parked automobile. Free places for automobiles: 7
Pickup owner parks its vehicle in temporary lot. Free places for pickups: 3
Attendant parked pickup. Free places for pickups: 4
Attendant parked automobile. Free places for automobiles: 8
Pickup owner parks its vehicle in temporary lot. Free places for pickups: 3
Attendant parked pickup. Free places for pickups: 4
Pickup owner parks its vehicle in temporary lot. Free places for pickups: 3
Automobile owner parks its vehicle in temporary lot. Free places for automobiles: 7
Attendant parked automobile. Free places for automobiles: 8
Attendant parked pickup. Free places for pickups: 4
Pickup owner parks its vehicle in temporary lot. Free places for pickups: 3
Pickup owner parks its vehicle in temporary lot. Free places for pickups: 2
Automobile owner parks its vehicle in temporary lot. Free places for automobiles: 7
Attendant parked automobile. Free places for automobiles: 8
Attendant parked pickup. Free places for pickups: 3
Pickup owner parks its vehicle in temporary lot. Free places for pickups: 2
Pickup owner parks its vehicle in temporary lot. Free places for pickups: 1
^C
SIGINT received. Cleaning threads.
berry@DESKTOP-O92GAB6:/mnt/c/Users/lafci/Desktop/GTU/4. sınıf/4. sinif 2. donem/System Programming/HW3$
```

As you can see the code gives different outputs in every run. The reason can be the non-deterministic scheduling of threads by the operating system. Non-deterministic scheduling means that the operating system's decision about which thread to run next is not predictable and can change every time you run the program.