Producer-Consumer Problem Implementation

Team Members and Contributions

1. Mohammed Furqan
   - Implemented the `insert_item()` function and producer thread logic
   - Wrote main() function and thread creation
   - Created test cases and documented results
   - Contributed to the README file
2. Kaifuddin Ahmed
   - Implemented the `remove_item()` function and consumer thread logic
   - Added producer/consumer IDs and timing information
   - Debugged synchronization issues
   - Documented observations and findings

Compilation and Execution Instructions

1. Ensure you have a C compiler installed (e.g., MinGW).
2. Open Command Prompt and navigate to the project directory.
3. Compile the program:

   gcc -o buffer.exe buffer.c -lpthread
4. Run the program:

   buffer.exe <sleep_time> <producer_threads> <consumer_threads>
   Example: buffer.exe 20 5 5

5. To save output to a file:
   buffer.exe 20 5 5 > output.txt
   ```

## Program Behavior

- The program implements a producer-consumer scenario using a shared buffer.
- It uses semaphores and mutex locks for synchronization.
- Producers generate random integers and insert them into the buffer.
- Consumers remove integers from the buffer.
- The program prints the buffer state after each operation.
- Producer and consumer IDs are displayed for each action.
- Timestamps for attempts and successful operations are shown.

## Screenshots

```
C:\Users\furqan\OneDrive - csudh.edu\Documents\CSUDH\SEM 4 ( Fall 2024)\CSC-541 Advanced Operating Systems\Project2>buffer.exe 20 5 5
Consumer 2 tries to consume at time 1728159510
Consumer 4 tries to consume at time 1728159510
Consumer 3 tries to consume at time 1728159510
Consumer 1 tries to consume at time 1728159510
Producer 4 tries to insert 449 at time 1728159510
Producer 4 produced 449 at time 1728159510
slot 0: 449
slot 1: -1
slot 2: -1
slot 3: -1
slot 4: -1

Producer 2 tries to insert 449 at time 1728159510
Producer 0 tries to insert 449 at time 1728159510
Producer 1 tries to insert 449 at time 1728159510
Consumer 0 tries to consume at time 1728159510
Producer 3 tries to insert 449 at time 1728159510
Consumer 2 consumed 449 at time 1728159510
slot 0: -1
slot 1: -1
slot 2: -1
slot 3: -1
slot 4: -1

Producer 2 produced 449 at time 1728159510
slot 0: -1
slot 1: 449
slot 2: -1
slot 3: -1
slot 4: -1

Consumer 4 consumed 449 at time 1728159510
slot 0: -1
slot 1: -1
slot 2: -1
slot 3: -1
slot 4: -1

Producer 1 produced 449 at time 1728159510
slot 0: -1
slot 1: -1
slot 2: 449
slot 3: -1
slot 4: -1
```

```
C:\Windows\System32\cmd.e        ×     +   ∨                                                                                         –    □    ×
Producer 3 produced 449 at time 1728159510
slot 0: -1
slot 1: -1
slot 2: 449
slot 3: 449
slot 4: -1

Consumer 1 consumed 449 at time 1728159510
slot 0: -1
slot 1: -1
slot 2: -1
slot 3: 449
slot 4: -1

Consumer 3 consumed 449 at time 1728159511
slot 0: -1
slot 1: -1
slot 2: -1
slot 3: -1
slot 4: -1

Producer 0 produced 449 at time 1728159511
slot 0: -1
slot 1: -1
slot 2: -1
slot 3: -1
slot 4: 449

Consumer 0 consumed 449 at time 1728159511
slot 0: -1
slot 1: -1
slot 2: -1
slot 3: -1
slot 4: -1

Consumer 2 tries to consume at time 1728159512
Consumer 4 tries to consume at time 1728159512
Consumer 1 tries to consume at time 1728159513
Consumer 3 tries to consume at time 1728159513
Consumer 0 tries to consume at time 1728159513
Producer 4 tries to insert 474 at time 1728159514
Producer 4 produced 474 at time 1728159514
slot 0: 474
slot 1: -1
slot 2: -1
slot 3: -1
slot 4: -1

Consumer 2 consumed 474 at time 1728159514
slot 0: -1
slot 1: -1
```

```
Consumer 2 consumed 474 at time 1728159514
slot 0: -1
slot 1: -1
slot 2: -1
slot 3: -1
slot 4: -1

Producer 2 tries to insert 474 at time 1728159514
Producer 2 produced 474 at time 1728159515
slot 0: -1
slot 1: 474
slot 2: -1
slot 3: -1
slot 4: -1

Producer 3 tries to insert 474 at time 1728159515
Producer 1 tries to insert 474 at time 1728159515
Consumer 4 consumed 474 at time 1728159515
slot 0: -1
slot 1: -1
slot 2: -1
slot 3: -1
slot 4: -1

Producer 0 tries to insert 474 at time 1728159515
Producer 3 produced 474 at time 1728159515
slot 0: -1
slot 1: -1
slot 2: 474
slot 3: -1
slot 4: -1

Producer 1 produced 474 at time 1728159515
slot 0: -1
slot 1: -1
slot 2: 474
slot 3: 474
slot 4: -1

Producer 0 produced 474 at time 1728159515
slot 0: -1
slot 1: -1
slot 2: 474
slot 3: 474
slot 4: 474

Consumer 1 consumed 474 at time 1728159515
slot 0: -1
slot 1: -1
slot 2: -1
slot 3: 474
```

```
Consumer 1 consumed 474 at time 1728159515
slot 0: -1
slot 1: -1
slot 2: -1
slot 3: 474
slot 4: 474

Consumer 3 consumed 474 at time 1728159515
slot 0: -1
slot 1: -1
slot 2: -1
slot 3: -1
slot 4: 474

Consumer 0 consumed 474 at time 1728159515
slot 0: -1
slot 1: -1
slot 2: -1
slot 3: -1
slot 4: -1

Consumer 2 tries to consume at time 1728159518
Producer 4 tries to insert 709 at time 1728159518
Producer 4 produced 709 at time 1728159518
slot 0: 709
slot 1: -1
slot 2: -1
slot 3: -1
slot 4: -1

Consumer 2 consumed 709 at time 1728159518
slot 0: -1
slot 1: -1
slot 2: -1
slot 3: -1
slot 4: -1

Consumer 2 tries to consume at time 1728159519
Producer 2 tries to insert 709 at time 1728159519
Producer 2 produced 709 at time 1728159519
slot 0: -1
slot 1: 709
slot 2: -1
slot 3: -1
slot 4: -1

Consumer 2 consumed 709 at time 1728159519
slot 0: -1
slot 1: -1
slot 2: -1
```

```
slot 4: -1

Consumer 2 consumed 709 at time 1728159519
slot 0: -1
slot 1: -1
slot 2: -1
slot 3: -1
slot 4: -1

Consumer 4 tries to consume at time 1728159519
Producer 3 tries to insert 709 at time 1728159519
Producer 3 produced 709 at time 1728159519
slot 0: -1
slot 1: -1
slot 2: 709
slot 3: -1
slot 4: -1

Consumer 4 consumed 709 at time 1728159519
slot 0: -1
slot 1: -1
slot 2: -1
slot 3: -1
slot 4: -1

Consumer 4 tries to consume at time 1728159519
Producer 0 tries to insert 709 at time 1728159519
Producer 0 produced 709 at time 1728159519
slot 0: -1
slot 1: -1
slot 2: -1
slot 3: 709
Consumer 1 tries to consume at time 1728159519
Producer 1 tries to insert 709 at time 1728159519
slot 4: -1

Producer 1 produced 709 at time 1728159519
slot 0: -1
slot 1: -1
slot 2: -1
slot 3: 709
slot 4: 709

Consumer 4 consumed 709 at time 1728159519
slot 0: -1
slot 1: -1
slot 2: -1
slot 3: -1
slot 4: 709
```

```
Consumer 3 tries to consume at time 1728159526
Consumer 3 consumed 440 at time 1728159526
slot 0: 117
slot 1: 440
slot 2: 117
slot 3: 440
slot 4: -1

Producer 4 produced 811 at time 1728159526
slot 0: 117
slot 1: 440
slot 2: 117
slot 3: 440
slot 4: 811

Producer 0 tries to insert 811 at time 1728159527
Producer 4 tries to insert 491 at time 1728159527
Consumer 2 tries to consume at time 1728159528
Consumer 2 consumed 117 at time 1728159528
slot 0: -1
slot 1: 440
slot 2: 117
slot 3: 440
slot 4: 811

Producer 2 produced 811 at time 1728159528
slot 0: 811
slot 1: 440
slot 2: 117
slot 3: 440
slot 4: 811

Consumer 4 tries to consume at time 1728159528
Consumer 4 consumed 440 at time 1728159528
slot 0: 811
slot 1: -1
slot 2: 117
slot 3: 440
slot 4: 811

Producer 3 produced 811 at time 1728159528
slot 0: 811
slot 1: 811
slot 2: 117
slot 3: 440
slot 4: 811

Producer 2 tries to insert 491 at time 1728159529
Producer 3 tries to insert 491 at time 1728159529

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```