Advanced Operating Systems
Project-3 Group 2

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Objective:

The goal is to gain hands-on experience with multithreading using the pthreads library. We've created a C program that simulates multiple ticket sellers simultaneously selling concert tickets over the course of one hour, employing the pthreads library for thread and mutex management.

Overview:

At the start of the program, there are ten separate customer queues, each containing N customers. These queues track the customer's ID, arrival time, and service duration, all measured in minutes. Every customer is set to arrive at the start of a specific minute. Following this, each seller is assigned a customer queue to handle the incoming customers. Sellers are divided into three categories: L, M, and H, which determine their service speed and seating strategy. When serving a customer, a seller selects an available seat based on their category. A seat is available if its mutex is unlocked, ensuring only one seller can reserve it. Once a seat mutex is locked, the seller records details like response time, total service time, and the seller's type for that seat. This process continues until all seats are filled or the one-hour limit is reached. Customers who remain unserved are notified that no seats are available. After the simulation ends, metrics like average response time, service time, and throughput for each seller type are calculated. Common variables across functions include the total customers per seller, the main clock timer, pthread parameters, and seat-related data structures.

The model was built using initial code, where the main thread simulated clock increments, while critical sections and ticket sales were handled by secondary threads representing the ticket-selling process. The main thread in the simulation generates minute-by-minute clock ticks.

Simulation Assumptions:

1. **Seller Thread States**: At any given time, a seller thread can be in one of the following states:
   - **Idle:** Waiting for the next customer.
   - **Attending:** Serving a new customer from their queue.
   - **Finalizing:** Completing the sales process for a customer.
   - **Operational:** Actively performing the sales task.

2. **Time Unit:** The smallest time unit tracked is a minute. Each individual thread represents the activities that take place within a minute, such as assisting a customer or finishing a sale.

3. **Time Synchronization:** A new clock tick is triggered to maintain synchronized timing across all threads.

4. **Concert Seating Representation:** A two-dimensional matrix is used to represent the concert seating. It is assumed that at any given moment, only one thread interacts with the matrix, ensuring no conflicts in seat allocation.

We also calculated Average Response Time, Average Turnaround Time and Throughput which came out to be:

	Average Response Time	Average Turnaround Time	Throughput
H	0.000000	32.60	0.08
L	0.666667	30.40	0.25
M	0.733333	29.27	0.47

Output:

```
(base) vedantrajkavi@vedants-MacBook-Pro Project3 % ./main 5

Thread simulation starts here:
----------------------------------------------------------------------------
Time     SellerName     Activity                      Response Time   Turnaround Time
----------------------------------------------------------------------------
00:00    M2             Customer No M201 arrived
00:00    M2             Serving Customer No M201              0
00:02    M2             Customer No M202 arrived
00:03    L1             Customer No L101 arrived
00:03    L1             Serving Customer No L101              0
00:04    M2             Customer No M201 assigned seat 5,0                   4
00:05    L6             Customer No L601 arrived
00:05    L6             Serving Customer No L601              0
00:05    M2             Customer No M203 arrived
00:05    M2             Serving Customer No M202              3
00:05    L5             Customer No L501 arrived
00:05    L5             Serving Customer No L501              0
00:07    L3             Customer No L301 arrived
00:07    L3             Serving Customer No L301              0
00:07    M3             Customer No M301 arrived
00:07    M3             Serving Customer No M301              0
00:07    H1             Customer No H101 arrived
00:07    H1             Serving Customer No H101              0
00:07    L5             Customer No L502 arrived
00:08    L1             Customer No L101 assigned seat 9,9                   8
00:08    M2             Customer No M202 assigned seat 5,1                   8
00:08    L6             Customer No L602 arrived
00:08    H1             Customer No H101 assigned seat 0,0                   8
00:09    L1             Customer No L102 arrived
00:09    L1             Serving Customer No L102              0
00:09    L6             Customer No L601 assigned seat 9,8                   9
00:09    M3             Customer No M301 assigned seat 5,2                   9
00:09    M2             Serving Customer No M203              4
00:09    L5             Customer No L501 assigned seat 9,7                   9
00:10    H1             Customer No H102 arrived
00:10    H1             Serving Customer No H102              0
00:10    L6             Serving Customer No L602              2
00:10    L5             Serving Customer No L502              3
00:11    H1             Customer No H102 assigned seat 0,1                   11
00:12    M2             Customer No M204 arrived
00:12    M2             Customer No M203 assigned seat 5,3                   12
00:13    M2             Serving Customer No M204              1
00:13    L3             Customer No L301 assigned seat 9,6                   13
00:13    L5             Customer No L503 arrived
00:15    L5             Customer No L502 assigned seat 9,5                   15
00:15    L1             Customer No L102 assigned seat 9,4                   15
00:16    L6             Customer No L602 assigned seat 9,3                   16
00:16    L5             Serving Customer No L503              3
00:17    M2             Customer No M204 assigned seat 5,4                   17
00:17    L1             Customer No L103 arrived
00:17    L1             Serving Customer No L103              0
00:18    L2             Customer No L201 arrived
00:18    L2             Serving Customer No L201              0
00:19    L4             Customer No L401 arrived
00:19    L4             Serving Customer No L401              0
00:21    L4             Customer No L402 arrived
00:21    L5             Customer No L503 assigned seat 9,2                   21
00:22    L1             Customer No L103 assigned seat 9,1                   22
00:23    L4             Customer No L401 assigned seat 9,0                   23
00:23    M1             Customer No M101 arrived
00:23    M1             Serving Customer No M101              0
00:23    M3             Customer No M302 arrived
00:23    M3             Serving Customer No M302              0
00:23    L2             Customer No L201 assigned seat 8,9                   23
00:24    L4             Serving Customer No L402              3
00:24    M1             Customer No M102 arrived
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00:25    M1              Customer No M101 assigned seat 5,5             25
00:26    L3              Customer No L302 arrived
00:26    L3              Serving Customer No L302           0
00:26    M1              Serving Customer No M102           2
00:26    M3              Customer No M302 assigned seat 5,6             26
00:27    M2              Customer No M205 arrived
00:27    M2              Serving Customer No M205           0
00:29    M1              Customer No M102 assigned seat 5,7             29
00:30    M2              Customer No M205 assigned seat 5,8             30
00:30    L4              Customer No L402 assigned seat 8,8             30
00:31    L6              Customer No L603 arrived
00:31    L6              Serving Customer No L603           0
00:31    L3              Customer No L302 assigned seat 8,7             31
00:32    M1              Customer No M103 arrived
00:32    M1              Serving Customer No M103           0
00:32    L5              Customer No L504 arrived
00:32    L5              Serving Customer No L504           0
00:32    L3              Customer No L303 arrived
00:32    L3              Serving Customer No L303           0
00:33    L2              Customer No L202 arrived
00:33    L2              Serving Customer No L202           0
00:33    L4              Customer No L403 arrived
00:33    L4              Serving Customer No L403           0
00:35    M1              Customer No M103 assigned seat 5,9             35
00:36    L6              Customer No L603 assigned seat 8,6             36
00:36    L5              Customer No L505 arrived
00:36    L3              Customer No L303 assigned seat 8,5             36
00:37    L3              Customer No L304 arrived
00:37    L3              Serving Customer No L304           0
00:37    L6              Customer No L604 arrived
00:37    L6              Serving Customer No L604           0
00:38    M1              Customer No M104 arrived
00:38    M1              Serving Customer No M104           0
00:38    H1              Customer No H103 arrived
00:38    H1              Serving Customer No H103           0
00:38    L2              Customer No L202 assigned seat 8,4             38
00:38    L4              Customer No L403 assigned seat 8,3             38
00:39    L2              Customer No L203 arrived
00:39    L5              Customer No L504 assigned seat 8,2             39
00:39    L4              Customer No L404 arrived
00:39    L4              Serving Customer No L404           0
00:39    L2              Serving Customer No L203           0
00:40    M3              Customer No M303 arrived
00:40    M3              Serving Customer No M303           0
00:40    H1              Customer No H103 assigned seat 0,2             40
00:40    M1              Customer No M104 assigned seat 6,0             40
00:40    L1              Customer No L104 arrived
00:40    L1              Serving Customer No L104           0
00:40    L5              Serving Customer No L505           4
00:42    M3              Customer No M303 assigned seat 6,1             42
00:43    L6              Customer No L604 assigned seat 8,1             43
00:44    L4              Customer No L404 assigned seat 8,0             44
00:44    L3              Customer No L304 assigned seat 7,9             44
00:44    L1              Customer No L104 assigned seat 7,8             44
00:46    L2              Customer No L203 assigned seat 7,7             46
00:47    L5              Customer No L505 assigned seat 7,6             47
00:49    M1              Customer No M105 arrived
00:49    M1              Serving Customer No M105           0
00:49    H1              Customer No H104 arrived
00:49    H1              Serving Customer No H104           0
00:49    M3              Customer No M304 arrived
00:49    M3              Serving Customer No M304           0
00:49    L4              Customer No L405 arrived
00:49    L4              Serving Customer No L405           0
00:49    L1              Customer No L105 arrived
00:49    L1              Serving Customer No L105           0
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00:49   L4              Customer No L405 arrived
00:49   L4              Serving Customer No L405          0
00:49   L1              Customer No L105 arrived
00:49   L1              Serving Customer No L105          0
00:50   L3              Customer No L305 arrived
00:50   L3              Serving Customer No L305          0
00:50   H1              Customer No H104 assigned seat 0,3        50
00:51   M1              Customer No M105 assigned seat 6,2        51
00:52   M3              Customer No M305 arrived
00:53   M3              Customer No M304 assigned seat 6,3        53
00:53   H1              Customer No H105 arrived
00:53   H1              Serving Customer No H105         0
00:54   L6              Customer No L605 arrived
00:54   L6              Serving Customer No L605         0
00:54   M3              Serving Customer No M305         2
00:54   L4              Customer No L405 assigned seat 7,5        54
00:54   L3              Customer No L305 assigned seat 7,4        54
00:54   H1              Customer No H105 assigned seat 0,4        54
00:55   L1              Customer No L105 assigned seat 7,3        55
00:55   L2              Customer No L204 arrived
00:55   L2              Serving Customer No L204         0
00:56   M3              Customer No M305 assigned seat 6,4        56
00:56   L2              Customer No L205 arrived
00:58   L6              Customer No L605 assigned seat 7,2        58
00:60   L2              Ticket Sale Closed. Customer No L204 Leaves
00:60   L2              Ticket Sale Closed. Customer No L205 Leaves

Thread simulation Ended


Final Concert Seat Chart
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H101    H102    H103    H104    H105      -       -       -       -       -
  -       -       -       -       -       -       -       -       -       -
  -       -       -       -       -       -       -       -       -       -
  -       -       -       -       -       -       -       -       -       -
M201    M202    M301    M203    M204    M101    M302    M102    M205    M103
M104    M303    M105    M304    M305      -       -       -       -       -
  -       -     L605    L105    L305    L405    L505    L203    L104    L304
L404    L604    L504    L403    L202    L303    L603    L302    L402    L201
L401    L103    L503    L602    L102    L502    L301    L501    L601    L101


*****************************************
Multi-threaded Ticket Sellers
Input N = 05
*****************************************

  ------------------------------------------------------------
  |     | No of Customers | GotSeat  | Returned | Throughput|
  ------------------------------------------------------------
  | H |              5 |        5 |        0 | 0.08      |
  | M |             15 |       15 |        0 | 0.25      |
  | L |             30 |       28 |        2 | 0.47      |
  ------------------------------------------------------------


  -------------------------------------------------
  |     | Avg response Time | Avg turnaround time|
  -------------------------------------------------
  |  H | 0.000000          | 32.60              |
  |  L | 0.500000          | 30.37              |
  |  M | 0.800000          | 29.13              |
  -------------------------------------------------
(base) vedantrajkavi@vedants-MacBook-Pro Project3 %
```

Conclusion:

The results of our simulation reveal distinct differences in response and service times between the H, M, and L sellers. The total time required to process ticket sales creates a ripple effect; it not only prolongs the service time for each ticket but also increases the waiting time for the subsequent customers, impacting both response and service times. Furthermore, as more sellers follow a specific approach, the average time spent searching for available seats increases. With a high number of L sellers, the front rows filled up quickly, forcing L sellers to look for seats further back. In contrast, the number of H sellers has decreased.