Change Log

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January 2025 CSE 314: Operating System Sessional Assignment 3: IPC

Department of Computer Science and Engineering
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1   Scenario: The Shadows of Small Heath

The year is 1920, and Birmingham's industrial landscape presents a backdrop of constant activity and underlying tension. In the working-class district of Small Heath, where factory smoke mingles with the everyday bustle of urban life, the Peaky Blinders have established an extensive intelligence operation. The narrow cobblestone streets echo with the sounds of horse-drawn carts and the steady rhythm of industrial machinery, while the perpetual haze from coal-burning factories creates an atmosphere of both productivity and concealment.

Tommy Shelby has designed a sophisticated document distribution system that requires the coordination of N operatives, each assigned a numerical identifier from 1 to N. The operation depends on precise synchronization among these operatives, who work in predetermined groups to ensure operational security. The consequences of failure extend beyond mere disappointment—discovery could result in serious legal repercussions or violent retaliation from competing criminal organizations seeking to establish their own dominance in Birmingham's underworld.

The organizational structure divides operatives into units of exactly M members each (where $N = cM$, with c representing a positive integer). Group formation follows a systematic approach: when M equals 3, operatives 1, 2, and 3 constitute the first unit or group, operatives 4, 5, and 6 form the second unit, and this pattern continues throughout the operation. Each unit must successfully complete a two-phase process to accomplish their mission of distributing intelligence documents throughout Birmingham's extensive underground network.

The operation progresses through two distinct phases, each presenting unique challenges and requiring careful coordination. Within each unit, the operative holding the highest identification number assumes leadership responsibilities, bearing ultimate accountability for the group's success and the safety of fellow members.

Document Recreation Phase: Each operative independently visits one of several clandestine printing facilities strategically located throughout Birmingham's industrial quarter. Using specialized typewriting equipment, they carefully recreate their assigned portion of the intelligence document. Upon completion, they deliver their work to their designated group leader, maintaining the security principle that no individual operative possesses complete information.

Logbook Entry Phase: Following successful collection of all document portions from their unit members, group leaders proceed to the central intelligence hub. This facility, housed within an unremarkable building that serves as the operational nerve center, maintains the master logbook. Leaders must record their completed operation in this heavily secured document, which tracks all intelligence activities across the Birmingham network.

2   Operational Challenges and Synchronization

The execution of this operation faces several practical constraints that require careful management and coordination among all participants.

Challenge #1: The operation has access to only four typewriting stations (TS1, TS2, TS3, TS4) distributed across Birmingham's industrial quarter. These stations are concealed within legitimate business establishments to avoid detection. Station assignment follows a specific protocol: operatives are assigned to stations based on the formula (operative ID mod 4 + 1). For example, operative 4 uses TS1, operative 1 uses TS2, and so forth. Operatives do not arrive simultaneously due to various factors including surveillance patterns, patrol schedules, and other operational considerations. When an operative arrives at an occupied station, they must wait, which increases exposure risk with each passing moment.

Challenge #2: The central intelligence hub maintains a single master logbook that serves as the authoritative record of all operations. Only one group leader may make entries at any given time, as simultaneous writing would create inconsistencies that could compromise the entire operation's security. However, multiple personnel may review existing entries while no writing is taking place, allowing for continuous information flow essential to ongoing operations.

3   Operational Tasks

3.1   Task #1: Station Assignment Protocol

When an operative arrives at their assigned typewriting station and finds it occupied, they must wait in a nearby concealed location. Upon completing their typewriting work, operatives follow a communication protocol to signal station availability. The departing operative alerts all operatives who may be waiting at the concealed location for that specific station, ensuring efficient resource utilization and minimal exposure time.

Your objective is to implement this coordination system, ensuring that no operative experiences indefinite waiting while maintaining operational security through proper synchronization mechanisms.

3.2   Task #2: Intelligence Hub Access Control

After group leaders collect document portions from every member of their unit, they proceed to the central intelligence hub to record their operation in the master logbook. They may only make entries when no other personnel are reading or writing in the logbook. Two intelligence staff members monitor the logbook continuously: one provides periodic operational progress reports to Thomas Shelby, while another maintains status updates on information boards. This scenario must be implemented using reader-writer problem principles, where writers must wait until all readers complete their current activities.

4   Implementation Requirements

- **No Busy Waiting:** Continuous availability checking (busy waiting) is prohibited throughout the implementation.

- **Randomized Arrival:** Generate all operatives simultaneously but introduce random delays before they begin the document recreation phase to simulate realistic operational conditions and varying arrival times.

- **Poisson Distribution:** Use Poisson distribution to generate random timing values. Select an appropriate inter-arrival rate that reflects realistic operational constraints.

- **Timing Implementation:** Implement operation timing using sleep functions. The relative time requirements for each operation are specified in the provided table.

- **Logbook Management:** The master logbook tracks the total number of completed operations using a shared variable (initially set to 0). Implement different random intervals for the two intelligence staff members who read the logbook. For example, Staff 1 might read at time 1, Staff 2 begins reading at time 3 while Staff 1 continues reading, then Staff 1 reads again at time 8. Readers should remain active in the system from initialization, using appropriate randomness to demonstrate concurrent access patterns.

- **Detailed Logging:** Print comprehensive information about each operative's actions, including precise timing information. Sample output formats are provided to demonstrate expected formatting standards.

Operation	Relative Time Unit
Document Recreation	x
Logbook Entry	y

4.1   Input/Output Specifications

- You will take input from a file and give output in an output file

- Input file format:

```
N M
x y
```

Where N = Number of operatives, M = Unit size, x, y = relative time units

5   Sample Execution

Input:

```
15 5
10 3
```

Example Output (Timings may not be same):

```
Operative 4 has arrived at typewriting station at time 4
Operative 2 has arrived at typewriting station at time 5
Operative 1 has arrived at typewriting station at time 7
Operative 3 has arrived at typewriting station at time 8
Operative 6 has arrived at typewriting station at time 10
Operative 7 has arrived at typewriting station at time 10
Operative 5 has arrived at typewriting station at time 12
Operative 8 has arrived at typewriting station at time 14
...
```

```
Intelligence Staff 1 began reviewing logbook at time 13. Operations completed = 0
Operative 4 has completed document recreation at time 14
Intelligence Staff 2 began reviewing logbook at time 17. Operations completed = 0
...
Unit 1 has completed document recreation phase at time 60
...
Intelligence Staff 2 began reviewing logbook at time 78. Operations completed = 0
Intelligence Staff 1 began reviewing logbook at time 82. Operations completed = 0
...
Unit 2 has completed intelligence distribution at time 95
Intelligence Staff 2 began reviewing logbook at time 98. Operations completed = 1
```

The timestamps and sequence demonstrate the coordination required for successful operation execution within the related setting.

6   Evaluation Criteria

Task	Subtask	Marks
Task 1	Randomized operative arrival at stations	15
	Station availability detection without busy waiting	25
	Proper notification of all waiting operatives	15
Task 2	Implementation of reader-writer problem with readers having higher priority	25
Documentation	Printing moves of operatives/groups	5
	Timing information integration	10
	Random delays using sleep to simulate realistic scenarios	5

7   Submission Protocol

- Create a directory named with your 7-digit student ID (2105XXX)

- Place all source code within this directory

- Compress the folder and rename to `2105XXX.zip`

- Submit the compressed archive

Deadline: June 21, 2025, 11:45 PM

8   Academic Integrity

- Plagiarism can result in complete -100%

- Complete all work independently