Elevator System Simulation Report

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**Assumptions**

While designing the elevator system, the following assumptions were made:

1. **Single and Multi-Elevator Systems**: The algorithm is designed to handle both single and multiple elevators efficiently.
2. **Request Timing**: Requests are generated randomly with a probability to simulate real-world usage patterns.
3. **Direction Consistency**: Elevators continue in their current direction unless there are no requests in that direction.
4. **Floor Numbers**: Floors are indexed from 0 to (total number of floors - 1).
5. **Immediate Assignment**: Requests are assigned to elevators at the moment they are generated, and unassignable requests are re-evaluated periodically.

These assumptions ensure that the simulation remains simple yet realistic, balancing computational efficiency and real-world applicability.

**Goals**

**1. Efficient Request Handling**

* **Problem Definition**: The system needs to handle multiple user requests efficiently and minimize wait times.
* **Algorithm Design**:
  + **Optimal Elevator Selection**: Requests are assigned to the nearest elevator, prioritizing those moving in the same direction as the request.
  + **Pending Request Management**: Requests that cannot be immediately processed are queued for reassignment.

This approach mirrors the **Minimum Distance First** strategy used in real-world elevators.

**2. Simplicity and Scalability**

* **Support for Single and Multi-Elevator Systems**: The system is designed to handle scenarios with one or more elevators.
* **Clear Structure**: The separation of responsibilities in the Elevator and ElevatorSystem classes simplifies maintenance and future enhancements.

**3. Realistic Request Processing**

* **Time-Based Simulation**: Randomized requests simulate realistic usage patterns.
* **Request Flow**: Each request includes a starting floor (from) and a destination floor (to), and the system outputs the status during processing.

**4. Priority Handling and Wait Time Minimization**

* **Priority Processing**: Requests matching the current direction of an elevator are processed first.
* **Wait Time Reduction**: The system minimizes unnecessary movement by prioritizing nearby requests.

**5. Readability and Learning**

* **Readable Code**: The structure is designed to be intuitive and easy to follow.
* **Learning-Oriented**: The system provides a straightforward implementation of an elevator simulation for educational purposes.

**6. Real-World Similarity**

* The algorithm emulates the decision-making processes of real-world elevators:
  + Maintains direction consistency.
  + Prioritizes closer requests.

**UML Class Diagram**

Below is a simplified UML class diagram representing the structure of the elevator system:

텍스트, 스크린샷, 폰트, 라인이(가) 표시된 사진

자동 생성된 설명

텍스트, 스크린샷, 폰트, 라인이(가) 표시된 사진

자동 생성된 설명

텍스트, 스크린샷, 폰트, 번호이(가) 표시된 사진

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**Efficiency of Algorithms**

**Significant Functions**

1. **addRequest**
   * **Description**: Adds a new request to the system's pending request queue.
   * **Complexity**: O(1) (simple insertion into the queue).
2. **assignRequests**
   * **Description**: Assigns pending requests to the most suitable elevator based on proximity and direction.
   * **Complexity**: O(n \* m), where **n** is the number of pending requests and **m** is the number of elevators. This is because each request is compared against all elevators to find the best match.
   * **Possible Improvement**: Using a priority queue or a more advanced data structure to maintain elevators' availability and proximity could potentially reduce the cost to O(n log m).
3. **stepSimulation**
   * **Description**: Updates the state of all elevators, processes requests, and moves elevators to their next floor.
   * **Complexity**: O(k), where **k** is the number of elevators (each elevator processes at most one task per step).
4. **printStatus**
   * **Description**: Outputs the current status of all elevators.
   * **Complexity**: O(k), where **k** is the number of elevators.

**Overall Complexity**

The dominant cost arises from the assignRequests function due to its O(n \* m) complexity. This could be further optimized with additional data structures, as noted above.

**Simulation Design**

**1. Random Request Generation**

* Requests are generated randomly using rand().
* Request generation probability is adjusted to prevent excessive loads.

**2. Time-Based Processing**

* The simulation advances in discrete time steps (t), performing the following tasks:
  1. Generate new requests.
  2. Assign requests to elevators.
  3. Update elevator states.
  4. Output system status.

**3. Output**

* The system outputs the status of all elevators and request processing progress at each time step.

Below is an example of the system’s output during execution:

텍스트, 스크린샷, 폰트, 문서이(가) 표시된 사진

자동 생성된 설명

**References**

1. **C++ Standard Library Documentation**: Utilized for understanding the behavior of STL containers like std::queue and std::vector.
2. **Elevator Algorithms**: General principles of elevator operation were referenced from [Wikipedia](https://en.wikipedia.org/wiki/Elevator_algorithm).
3. **Real-world Elevator Systems**: Observations from the functional behavior of elevators in real-life scenarios.