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**CSC 453**
**Assignment 8**

**Given the following sequence for page references:**

**1, 2, 3, 4, 5, 3, 4, 1, 6, 7, 8, 7, 8, 9, 7, 8, 9, 5, 4, 5, 4, 2**

**and the frequency of use (for LFU and MFU):**

| Page Number | Count |
|---|---|
| 1 | 876 |
| 2 | 234 |
| 3 | 789 |
| 4 | 312 |
| 5 | 340 |
| 6 | 181 |
| 7 | 633 |
| 8 | 511 |
| 9 | 444 |

1. **Assume that you have 3 frames available. Show how the pages would be loaded into frames assuming the following replacement algorithms:**
    1. **Optimum**

| | **1** | **2** | **3** | **4** | **5** | **3** | **4** | **1** | **6** | **7** | **8** | **7** | **8** | **9** | **7** | **8** | **9** | **5** | **4** | **5** | **4** | **2** |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| **F1** | 1 | 1 | 1 | 1 | 5 | | | 5 | 5 | 5 | 5 | | | 9 | | | | 5 | 5 | | | 2 |
| **F2** | | 2 | 2 | 4 | 4 | | | 4 | 4 | 4 | 8 | | | 8 | | | | 8 | 4 | | | 4 |
| **F3** | | | 3 | 3 | 3 | | | 1 | 6 | 7 | 7 | | | 7 | | | | 7 | 7 | | | 7 |

**2. FCFS (First Come First Serve)**

| | **1** | **2** | **3** | **4** | **5** | **3** | **4** | **1** | **6** | **7** | **8** | **7** | **8** | **9** | **7** | **8** | **9** | **5** | **4** | **5** | **4** | **2** |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| **F1** | 1 | 1 | 1 | 4 | 4 | | | 4 | 6 | 6 | 6 | | | 9 | | | | 9 | 9 | | | 2 |
| **F2** | | 2 | 2 | 2 | 5 | | | 5 | 5 | 7 | 7 | | | 7 | | | | 5 | 5 | | | 5 |
| **F3** | | | 3 | 3 | 3 | | | 1 | 1 | 1 | 8 | | | 8 | | | | 8 | 4 | | | 4 |

**3. LRU (Least Recently Used)**

| | **1** | **2** | **3** | **4** | **5** | **3** | **4** | **1** | **6** | **7** | **8** | **7** | **8** | **9** | **7** | **8** | **9** | **5** | **4** | **5** | **4** | **2** |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| **F1** | 1 | 1 | 1 | 4 | 4 | | | 4 | 4 | 7 | 7 | | | 7 | | | | 5 | 5 | | | 5 |
| **F2** | | 2 | 2 | 2 | 5 | | | 1 | 1 | 1 | 8 | | | 8 | | | | 8 | 4 | | | 4 |
| **F3** | | | 3 | 3 | 3 | | | 3 | 6 | 6 | 6 | | | 9 | | | | 9 | 9 | | | 2 |

**4. LFU (Least Frequently Used)**

| | **1** | **2** | **3** | **4** | **5** | **3** | **4** | **1** | **6** | **7** | **8** | **7** | **8** | **9** | **7** | **8** | **9** | **5** | **4** | **5** | **4** | **2** |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| **F1** | 1 | 1 | 1 | 1 | 1 | | 1 | | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 |
| **F2** | | 2 | 2 | 4 | 5 | | 4 | | 6 | 7 | 8 | 7 | 8 | 9 | 7 | 8 | 9 | 5 | 4 | 5 | 4 | 2 |
| **F3** | | | 3 | 3 | 3 | | 3 | | 3 | 3 | 3 | 3 | 3 | 3 | 3 | 3 | 3 | 3 | 3 | 3 | 3 | 3 |

**5. MFU (Most Frequently Used)**

| | **1** | **2** | **3** | **4** | **5** | **3** | **4** | **1** | **6** | **7** | **8** | **7** | **8** | **9** | **7** | **8** | **9** | **5** | **4** | **5** | **4** | **2** |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| **F1** | 1 | 1 | 1 | 4 | 4 | 4 | | 4 | 4 | 7 | 8 | 7 | 8 | 9 | 7 | 8 | 9 | 5 | 4 | 5 | 4 | |
| **F2** | | 2 | 2 | 2 | 2 | 2 | | 2 | 2 | 2 | 2 | 2 | 2 | 2 | 2 | 2 | 2 | 2 | 2 | 2 | 2 | |
| **F3** | | | 3 | 3 | 5 | 3 | | 1 | 6 | 6 | 6 | 6 | 6 | 6 | 6 | 6 | 6 | 6 | 6 | 6 | 6 | |

2. **Assume that Δ= 4, how many frames will this process be allocated**

   Since Δ = 4, there should be at least 4 frames for the process not to be thrashing.