Replacement Policies

CMPSCI 230 Computer Systems Principles
Objectives

- Cache Replacement Algorithms
  - Least Frequently Used (LFU)
  - Least Recently Used (LRU)
Replacement Policies

- Optimal Data Replacement Algorithm
  - Belady’s Algorithm:
    Replace the data that will not be used for the longest period of time in the future.

- Problem:
  - Need to predict the future!
  - Not possible, but used as a “yard stick” to compare replacement algorithms to determine improvement.
  - Use heuristics
Caching Algorithms

- Least Frequently Used (LFU)
- Least Recently Used (LRU)
Caching Algorithms (LFU)

- **Least Frequently Used (LFU)**
  - Count how often an entry is used by incrementing a counter associated with each entry in the cache.
  - Remove the entry with the least frequently used counter first.

- **Request Pattern**
  - Discard entries that are not needed over the longest period.
LFU Example

hit count:
LFU Example

hit count:
LFU Example

hit count:
LFU Example

hit count:
LFU Example

hit count:
LFU Example

hit count:
LFU Example

hit count:
LFU Example

hit count:
LFU Example

Evict Least Frequently Used

hit count:
LFU Example

hit count:
LFU Example

Cache Full

hit count:
LFU Example

Evict Least Frequently Used
LFU Example

hit count:
LFU Example

hit count:
LFU Example

Evict Least Frequently Used

hit count:
LFU Example

hit count:
LFU Example

hit count:
LFU Example

hit count:

Cache Full

2 4 1 7

2 1 3 1
LFU Example

Evict Least Frequently Used

hit count:
LFU Example

hit count:
LFU Example

hit count:
LFU Example

Final State of the Cache

hit count:
Caching Algorithms: LRU

- **Least Recently Used (LRU)**
  - New items are placed in the top of the cache. When cache exceeds size limit, discard items from the bottom.
  - **Remove the least recently used item first**

- **Request Pattern**
  - Discard entries that are least recently used
  - **Fast!**
LRU Example
LRU Example
LRU Example
LRU Example
LRU Example

2  1  3  8
4  1  8  8
7  1  4  2
LRU Example

2  1  3  8
4  1  8  8
7  1  4   
LRU Example

1  3  8
4  1  8  8
2  7  1  4
LRU Example

1 3 8
4 1 8 8
2 7 4
LRU Example
LRU Example
LRU Example
LRU Example
LRU Example

```
4  1  8  8

8  3  1  2
```
LRU Example
LRU Example
LRU Example
LRU Example

1 4 8 3

8 8
LRU Example
LRU Example
LRU Example

Final State of the Cache

8  1  4  3
LRU Example

Final State of the Cache