Data Structures

CSSE 221

Fundamentals of Software Development Honors

Rose-Hulman Institute of Technology

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The gem cannot be polished without friction, nor man perfected without trials.

-- Chinese Proverb

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This week: VectorGraphics

- Tuesday:
  - Lists and Iterators (capsule)
- Wednesday:
  - Threads (capsule)
  - Project workday
- Today:
  - Stacks and Queues
  - Sets and Maps

Stacks

- A last-in, first-out (LIFO) data structure
- Real-world stacks
  - Plate dispensers in the cafeteria
  - Pancakes!
- Some uses:
  - Tracking paths through a maze
  - Providing "unlimited undo" in an application

Operations Provided	Efficiency
Push item	O(1)
Pop item	O(1)

Implemented by Stack, LinkedList, and ArrayDeque in Java. An ArrayList also works

Queues

- A first-in, first-out (FIFO) data structure
- Real-world queues
  - Waiting line at the BMV
  - Character on Star Trek TNG
- Some uses:
  - Scheduling access to shared resource (e.g., printer)

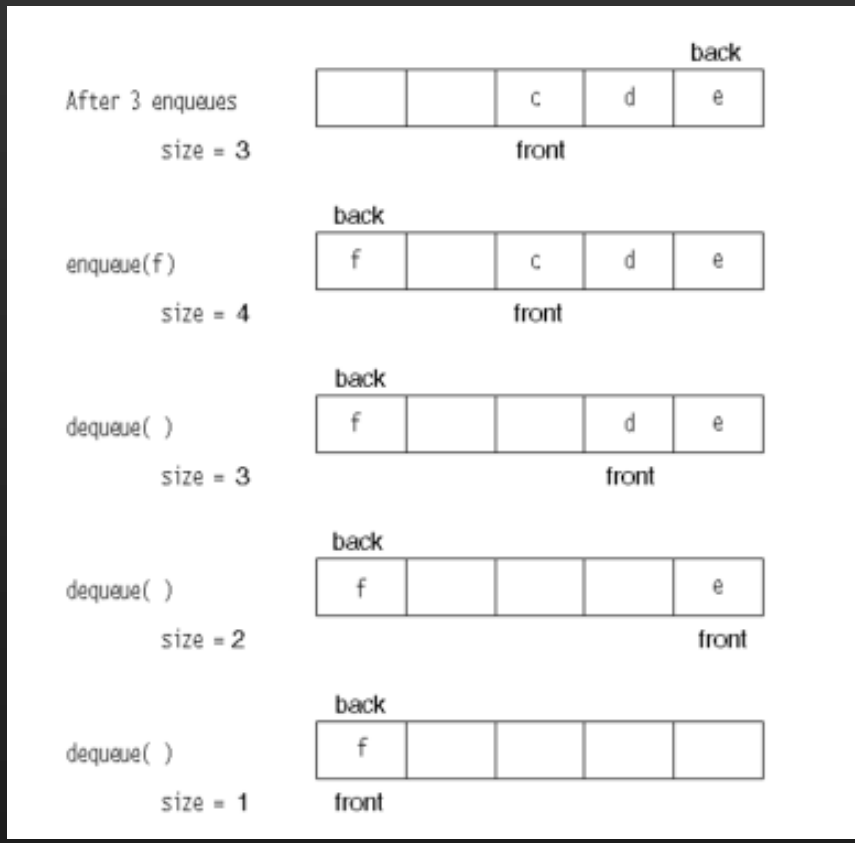
Operations Provided	Efficiency
Enqueue item	O(1)
Dequeue item	O(1)

Implemented by LinkedList and ArrayDeque in Java

Array implementation of queue

```
private int increment( int x )
{
    if( ++x == theArray.length )
        x = 0;
    return x;
}
```

What if we run out of room?



Demo

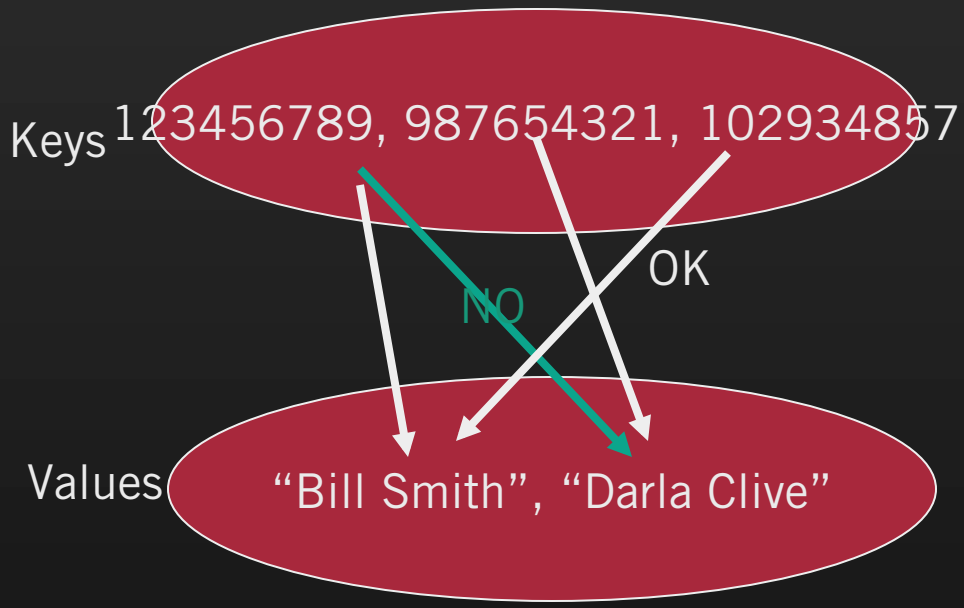
A tale of two interfaces: Set<E>…

- A collection with **no duplicates**
- If **obj1** and **obj2** are both in the set, then **obj1.equals(obj2)** returns false.
- Can .add() and .remove()
- Subinterface: SortedSet
- Even has intersection (**retainsAll()**) and union (**addAll()**) methods

…and Map<K,V>

```
HashMap<Integer, String> map =
new HashMap<Integer, String>();

map.put(123456789, "Bill Smith");
map.put(987654321, "Darla Clive");
```



- An object that maps keys to values. Duplicates?
  - A map cannot contain duplicate keys; each key can map to at most one value.
    `V get(Object key)`
  - Multiple keys **can** have the same value
- Other operations:
  - **put(K key, V value)**
  - **containsKey(Object key)**
  - **V remove(Object key)**

TreeSets and TreeMaps

- …are java.util implementations of SortedSet and Map.
- **Sorted** elements.
- In a tree, average time is O(log n),
  - and with complex algorithms, worst case can also be O(log n)
- Also support taking ordered subsets from head, tail, or interior of set or map

- Implement in CSSE230

HashSets and HashMaps

- …are java.util implementations of Set (not SortedSet) and Map.
- Average time for lookup, insertion, or deletion is O(1).
  - but worst case is O(N).
  - A quick view of how it works:
    - hashCode function maps object to an integer, which is used to find an index into an array
    - Resolve collisions
    - Fast search, but unordered
  - Need to use a class for your keys that implements .equals() and .hashCode() [or implement them]
- More details in CSSE230

Sets

- **C**ollections **without duplicates**
- Real-world sets
  - Students
  - Collectibles
- Some uses:
  - Quickly checking if an item is in a collection

Operations	HashSet	TreeSet
Add/remove item	O(1)	O(lg n)
Contains?	O(1)	O(lg n)

Can hog space

Sorts items!

Maps

- Associate unique keys with values
- Real-world "maps"
  - Dictionary
  - Phone book
- Some uses:
  - Associating student ID with transcript
  - Associating name with high scores

Operations	HashMap	TreeMap
Insert key-value pair	O(1)	O(lg n)
Look up value for key	O(1)	O(lg n)

Can hog space

Sorts items by key!

Demo