Priority Queue

Queuing, the smart way

Queue

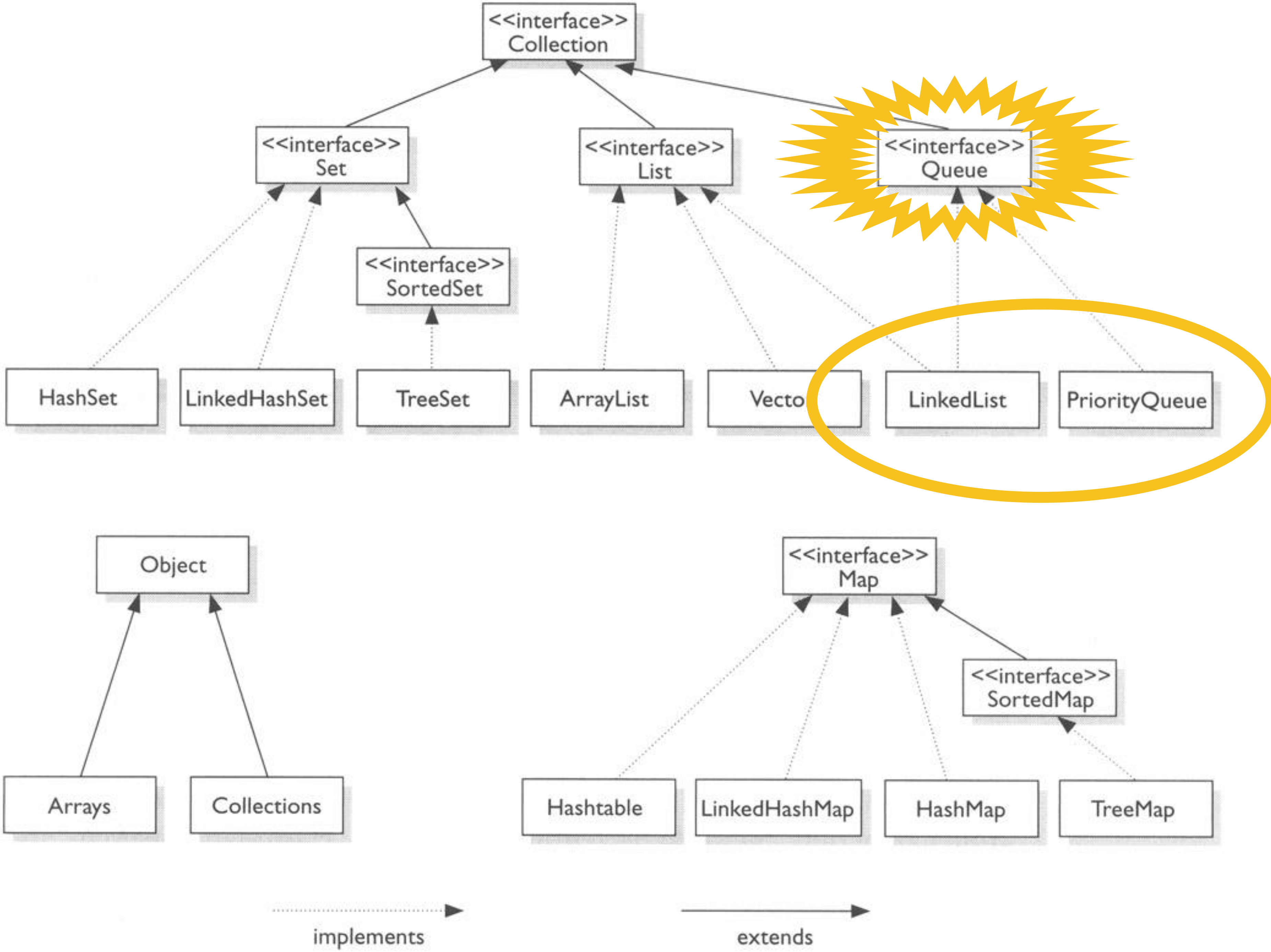
- First in, first out (FIFO)
- Easily implemented with a List
  - Also LIFO!

Priority Queue

- Prioritization problems
- Canonical example: ER scheduling
  - A gunshot victim should probably get treatment sooner than that one guy with a sore neck, regardless of arrival time. How do we always choose the most urgent case when new patients continue to arrive?

Poor choices

- list
  - remove max by searching is O(N)
- sorted list
  - remove max is O(1); add (remove) is O(N)
- binary search tree
  - remove max, add and remove are O(log N)
  - … but tree may becomes unbalanced


<<interface>> Collection
<<interface>> Set
<<interface>> List
<<interface>> Queue
<<interface>> SortedSet
HashSet
LinkedHashSet
TreeSet
ArrayList
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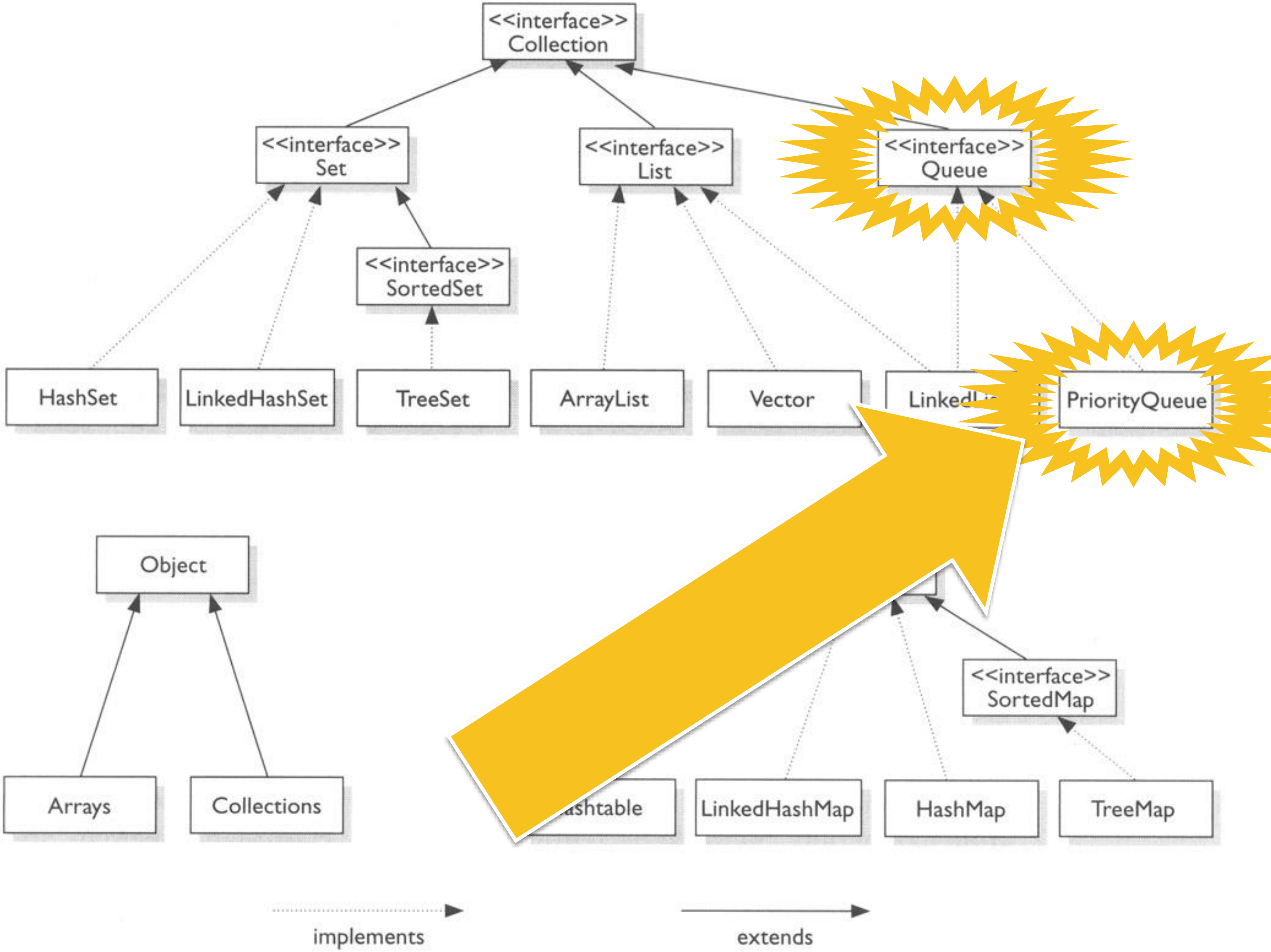
PriorityQueue
Object
Arrays
Collections
<<interface>> Map
<<interface>> SortedMap
Hashtable
LinkedHashMap
HashMap
TreeMap
implements
extends



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Queue interface

- Add elements
  - boolean **add**(element)
  - boolean **offer**(element)
- Remove elements
  - element **remove**()
  - element **poll**()
- Examine
  - element **element**()
  - element **peek**()

Queue Interface Structure

Type of Operation	Throws exception	Returns special value
Insert	`add(e)`	`offer(e)`
Remove	`remove()`	`poll()`
Examine	`element()`	`peek()`

Queues

- Known implementing classes:
  - ArrayBlockingQueue
  - ArrayDeque
  - ConcurrentLinkedQueue
  - DelayQueue
  - LinkedBlockingDeque
  - LinkedBlockingQueue
  - LinkedList
  - PriorityBlockingQueue
  - PriorityQueue
  - SynchronousQueue

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Supports operations that wait for the queue to become non-empty when retrieving an element, and wait for space to become available in the queue when storing an element

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Double ended queues support insertion and removal at both ends. The name *deque* is short for "double ended queue" and is usually pronounced "deck"

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An unbounded thread-safe queue

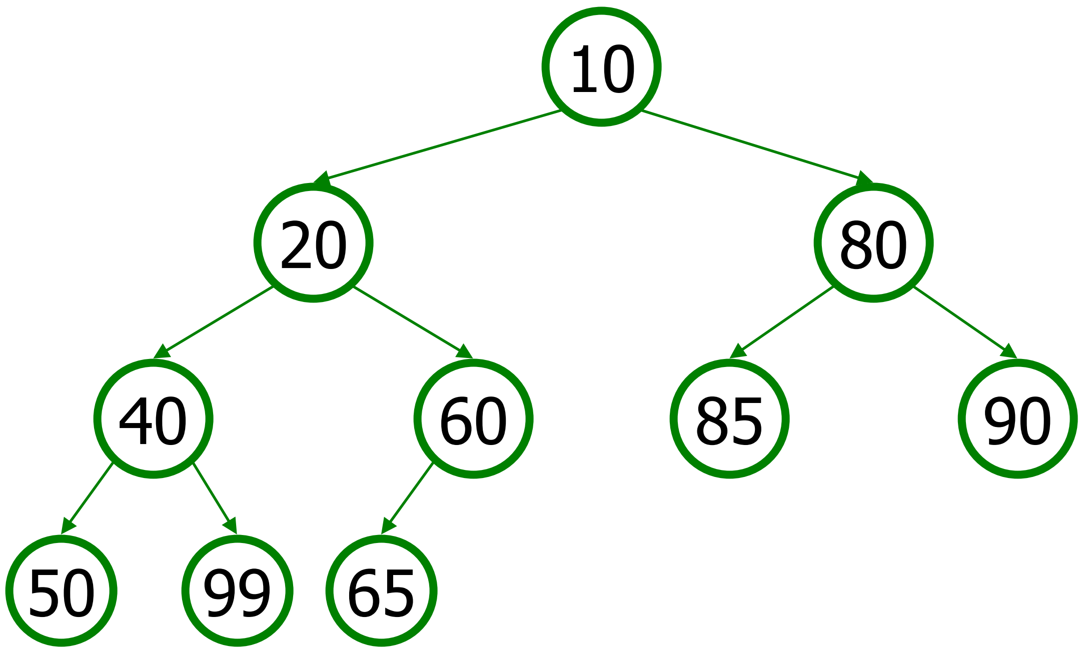
PriorityQueue

- An unbounded priority queue based on a priority heap.

Method/Constructor	Description	Runtime
`PriorityQueue<E>()`	constructs new empty queue	O(1)
`add(E value)`	adds value in sorted order	O(log *N*)
`clear()`	removes all elements	O(1)
`iterator()`	returns iterator over elements	O(1)
`peek()`	returns minimum element	O(1)
`remove()`	removes/returns min element	O(log *N*)
`size()`	number of elements in queue	O(1)

What is a Heap?

- Kind of binary tree
- “Partially” ordered



Example

```
Queue<String> pq = new PriorityQueue<String>();
pq.add("Homer");
pq.add("Marge");
pq.add("Bart");
pq.add("Lisa");
pq.add("Maggie");
...
```

Note

- For a priority queue to work, elements must have an ordering.
  - Elements must implement the *Comparable* interface

```
public class Foo implements Comparable<Foo> {
    …
    public int compareTo(Foo other) {
        // Return positive, zero, or negative integer
    }
}
```

  - The comparator must be specified in the constructor

```
public PriorityQueue(int initialCapacity,
                     Comparator<? super E> comparator)
```

Yet another possible use

- Dijkstra's original algorithm was $O(V^2)$
- Exploiting a special priority queue is $O(E + V \cdot \log V)$
- I.e., the fastest known single-source shortest-path algorithm for arbitrary directed graphs with unbounded non-negative weights

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