

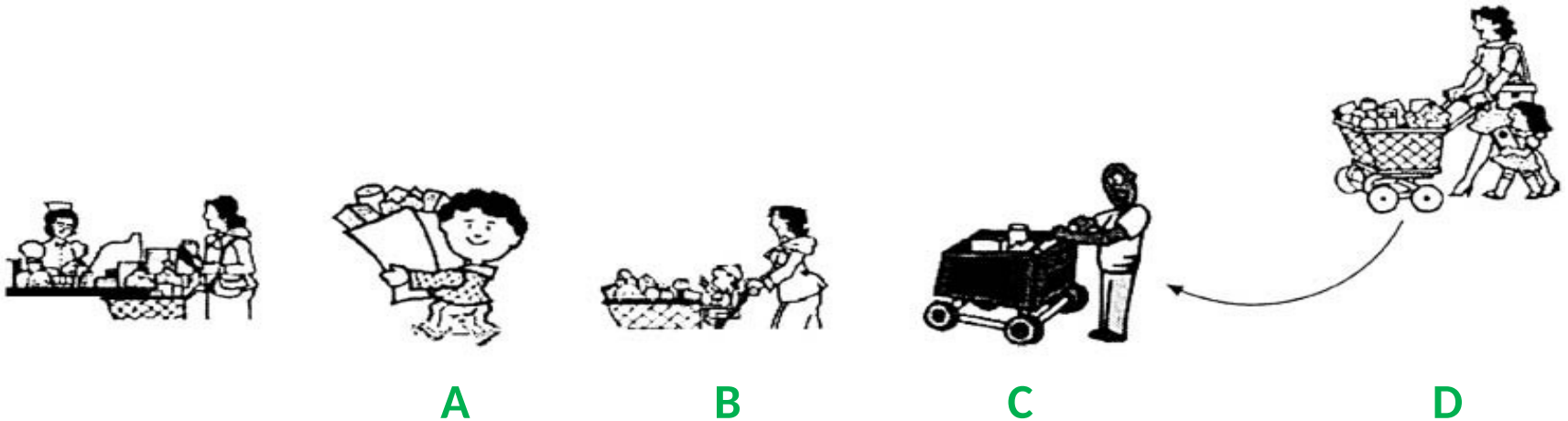
Queue & Priority Queue

WIA1002/ WIB1002 :

Data Structures

Queue

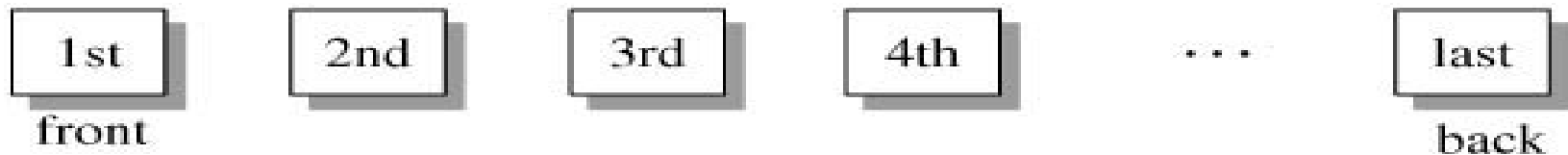
- A waiting line at a grocery store or a bank is a model of a queue.



- Which is first in this queue?
- Which is last?

Queues

- A queue represents a waiting list.
- A queue can be viewed as a special type of **list**, where the elements are **inserted** into the **end** (**back/tail**) of the **queue**, and are accessed and **deleted** from the **beginning** (**front/head**) of the **queue**.

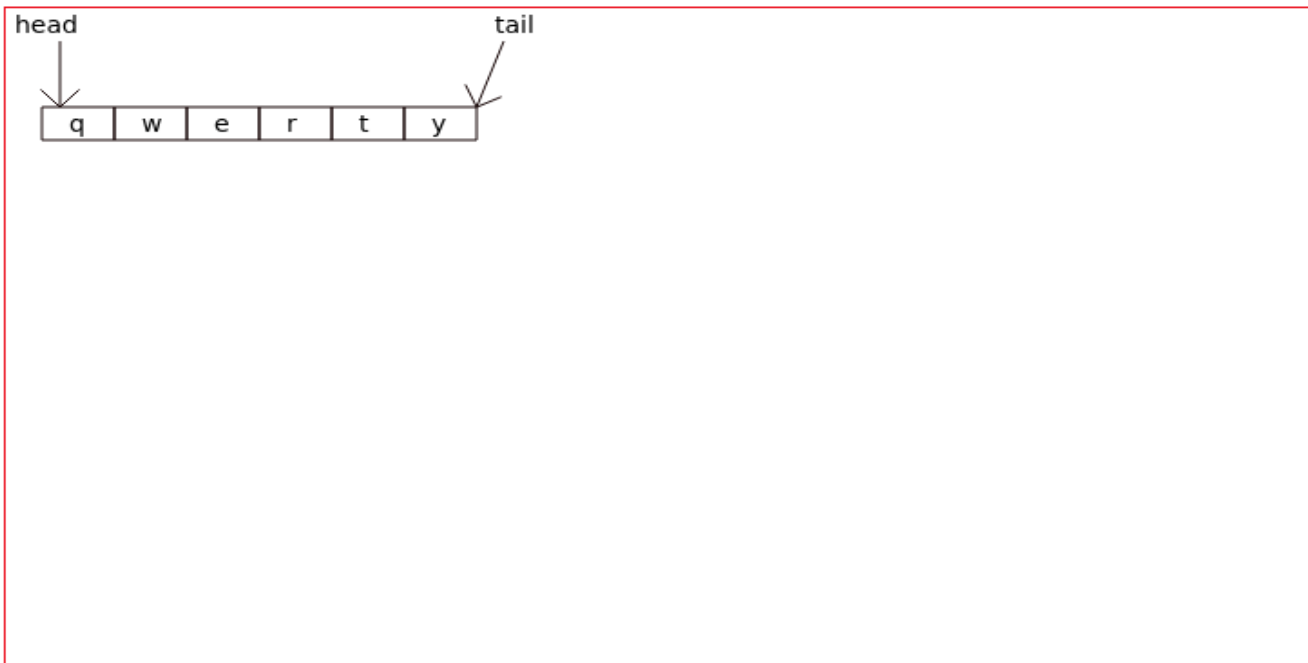


- An item **removed** from the queue is the **first** element that was added into the queue. A queue has **FIFO** (first-in-first-out) ordering.

Queue Animation

Queue [Animation](#) by [Y. Daniel Liang](#)

Usage: Enter a value and click the Enqueue button to append the value into the tail of the queue. Click the Dequeue button to remove the element from the head of the queue. Click the Start Over button to start over.



The diagram shows a horizontal array of six boxes containing the letters 'q', 'w', 'e', 'r', 't', and 'y'. An arrow labeled 'head' points to the first box ('q'). Another arrow labeled 'tail' points to the last box ('y').

Enter a value:

<https://yongdanielliang.github.io/animation/web/Queue.html>

Check Point

1. Where is element inserted and deleted from a queue?
2. What is this ordering called?

Check Point

1. Where is element inserted and deleted from a queue?

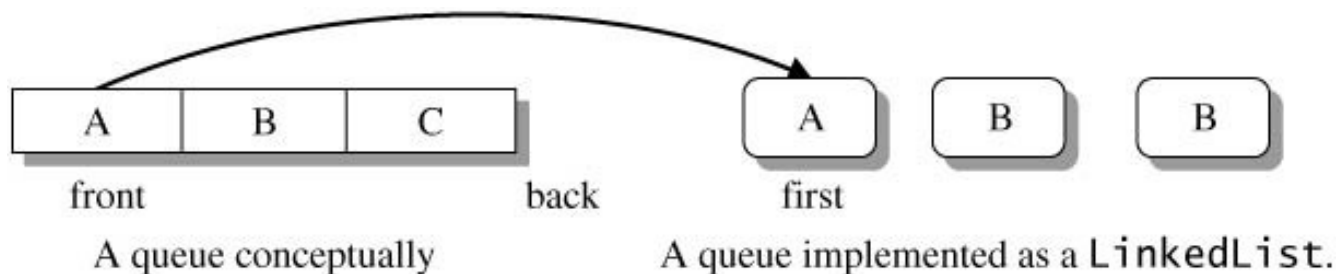
*The elements are **inserted** into the **end** (**back/tail**) of the **queue**, and are accessed and **deleted** from the **beginning** (**front/head**) of the **queue***

2. What is this ordering called?

FIFO (first-in-first-out) ordering.

Implementing Queue

- Since **deletions** are made at the **beginning** of the list, it is more efficient to implement a queue using a linked list than an array list.
- Using **LinkedList** to implement **Queue**



Methods/Operations in Queue

- Enqueue() → en(in) / add
- Dequeue() → delete

Implementing Queue

- two ways to design the queue class using LinkedList:
 - Using inheritance: You can define a queue (GenericQueue) class by extending LinkedList class
 - Using composition: You can define an linked list as a data field in the queue(GenericQueue) class



(a) Using inheritance



(b) Using composition

GenericQueue<E> Class

GenericQueue class using a LinkedList & composition approach.

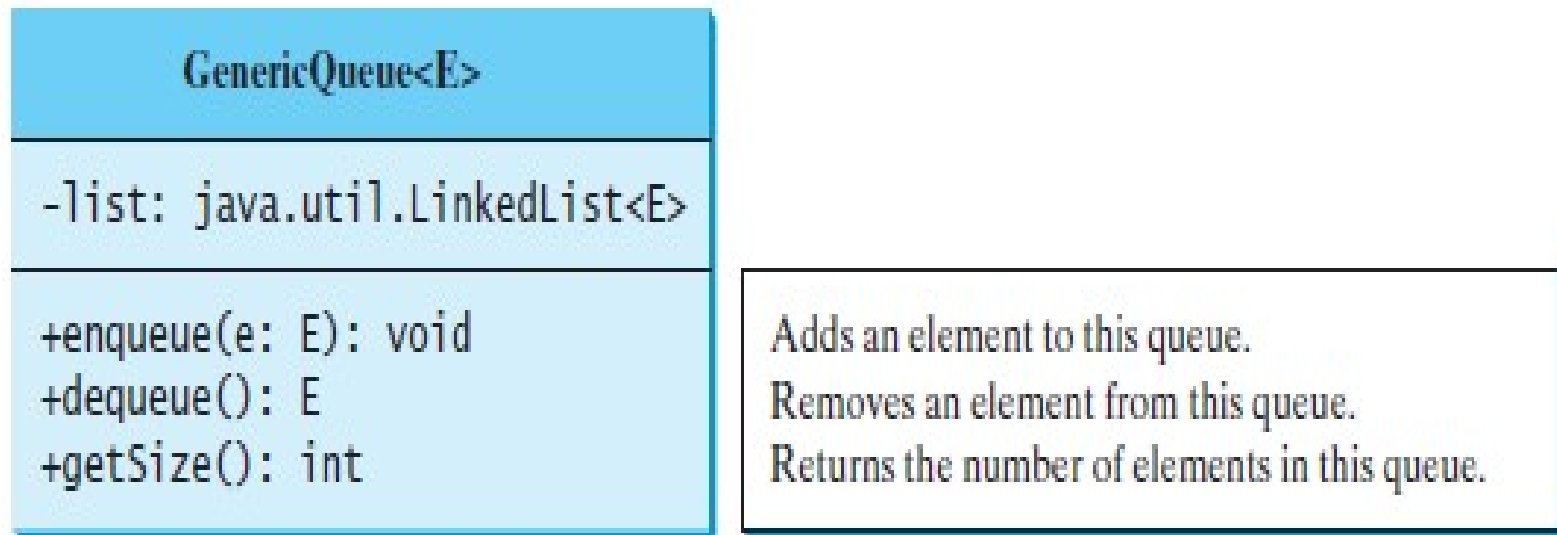


FIGURE 24.22 `GenericQueue` uses a linked list to provide a first-in, first-out data structure.

GenericQueue<E>

LISTING 24.7 GenericQueue.java

```
1  public class GenericQueue<E> {
2      private java.util.LinkedList<E> list
3          = new java.util.LinkedList<>();
4
5      public void enqueue(E e) {
6          list.addLast(e);
7      }
8
9      public E dequeue() {
10         return list.removeFirst();
11     }
12
13     public int getSize() {
14         return list.size();
15     }
16
17     @Override
18     public String toString() {
19         return "Queue: " + list.toString();
20     }
21 }
```

Test GenericQueue class

```
22
23 // Create a queue
24 GenericQueue<String> queue = new GenericQueue<>();
25
26 // Add elements to the queue
27 queue.enqueue("Tom"); // Add it to the queue
28 System.out.println("(7) " + queue);
29
30 queue.enqueue("Susan"); // Add it to the queue
31 System.out.println("(8) " + queue);
32
33 queue.enqueue("Kim"); // Add it to the queue
34 queue.enqueue("Michael"); // Add it to the queue
35 System.out.println("(9) " + queue);
36
37 // Remove elements from the queue
38 System.out.println("(10) " + queue.dequeue());
39 System.out.println("(11) " + queue.dequeue());
40 System.out.println("(12) " + queue);
41 }
42 }
```

```
(7) Queue: [Tom]
(8) Queue: [Tom, Susan]
(9) Queue: [Tom, Susan, Kim, Michael]
(10) Tom
(11) Susan
(12) Queue: [Kim, Michael]
```

Check Point

1. Which type of data structure is best to use to implement Queue?
2. What are the 2 important operations for Queue?

Check Point

1. Which type of data structure is best used to implement Queue?

Linked list

2. What are the 2 important operations for Queue?

enqueue & dequeue

Priority Queue

A **regular queue** is a **first-in and first-out (FIFO)** data structure. Elements are **appended** to the **end** of the **queue** and are **removed** from the **beginning** of the **queue**.

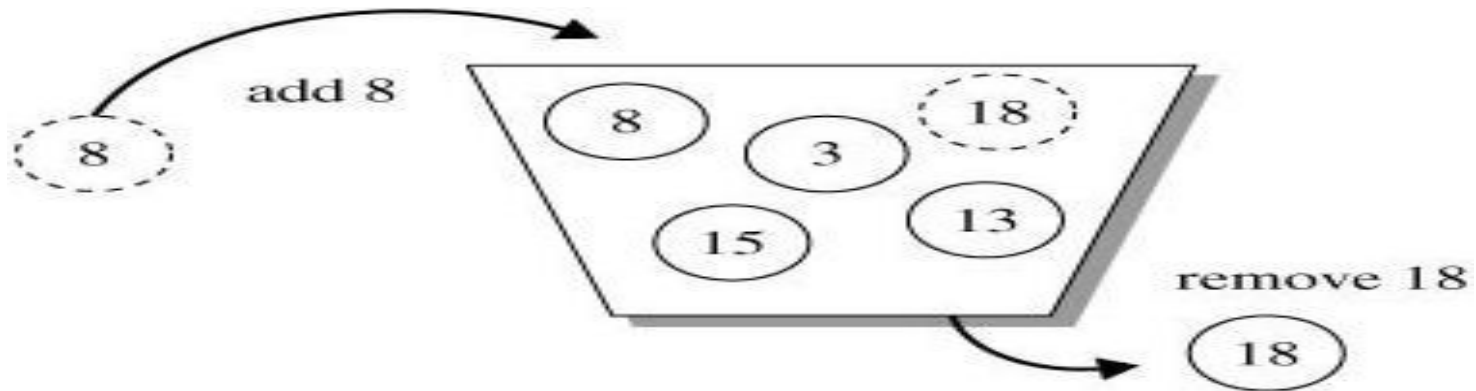
In a **priority queue**, **elements are assigned with priorities**. When accessing elements, the element with the **highest priority is removed first**.

A **priority queue** has a **largest-in, first-out** behavior (however you need to double check whether the larger the higher the priority, or the smaller the higher the priority).

For **example**, the emergency room in a hospital assigns priority numbers to patients; the patient with the highest priority is treated first. The assumption here the higher the number the higher the priority.

Priority Queue

- A priority queue is a collection in which all elements have a comparison (priority) ordering.
- It provides only simple access and update operations where a deletion always removes the element of highest priority



- In the above diagram, the assumption is the higher the number, the higher the priority.

The PriorityQueue Class from Java API

- import java.util.PriorityQueue
- Implemented interface java.util.Queue<E>

Constructors

Constructor and Description

PriorityQueue()

Creates a PriorityQueue with the default initial capacity (11) that orders its elements according to their **natural ordering**.

PriorityQueue(Collection<? extends E> c)

Creates a PriorityQueue containing the elements in the specified collection.

PriorityQueue(int initialCapacity)

Creates a PriorityQueue with the specified initial capacity that orders its elements according to their **natural ordering**.

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

Creates a PriorityQueue with the specified initial capacity that orders its elements according to the specified comparator.

PriorityQueue(PriorityQueue<? extends E> c)

Creates a PriorityQueue containing the elements in the specified priority queue.

PriorityQueue(SortedSet<? extends E> c)

Creates a PriorityQueue containing the elements in the specified sorted set.

PriorityQueue

- To add an element :
 - offer(E e) [returns boolean]
- To remove an object:
 - remove (Object o) [returns boolean]
- To retrieve, but not remove the head of the PriorityQueue:
 - peek () [returns E]
- To retrieve and remove the head of the PriorityQueue:
 - poll () [returns E]

PriorityQueue

- To clear the PriorityQueue:
 - `clear()` [void]
- To check the size of the Priority Queue :
 - `size()` [returns integer]
- To check whether object o is in the PriorityQueue:
 - `contains (Object o)` [returns boolean]

PriorityQueue Example

```
1 import java.util.*;
2
3 public class PriorityQueueDemo {
4     public static void main(String[] args) {
5         PriorityQueue<String> queue1 = new PriorityQueue<>();
6         queue1.offer("Oklahoma");
7         queue1.offer("Indiana");
8         queue1.offer("Georgia");
9         queue1.offer("Texas");
10        System.out.println("Priority queue using Comparable:");
11
12        while (queue1.size() > 0) {
13            System.out.print(queue1.poll() + " ");
14        }
15
16        PriorityQueue<String> queue2
17            = new PriorityQueue<>(4, Collections.reverseOrder());
18        queue2.offer("Oklahoma");
19        queue2.offer("Indiana");
20        queue2.offer("Georgia");
21        queue2.offer("Texas");
22        System.out.println("\nPriority queue using Comparator:");
23        while (queue2.size() > 0) {
24            System.out.print(queue2.poll() + " ");
25        }
26        System.out.println();
27    }
28 }
```

```
Priority queue using Comparable:
Georgia Indiana Oklahoma Texas
Priority queue using Comparator:
Texas Oklahoma Indiana Georgia
```

PriorityQueue Example2

```
1 public class Customer implements Comparable<Customer> {
2     private Integer id;
3     private String name;
4
5     public Customer(Integer id, String name) {
6         this.id = id;
7         this.name = name;
8     }
9
10    public Integer getID() {
11        return id;
12    }
13    public void setID(Integer id) {
14        this.id = id;
15    }
16    public String getName() {
17        return name;
18    }
19    public void setName(String name) {
20        this.name = name;
21    }
22
23    @Override
24    public int compareTo(Customer c) {
25        return this.getID().compareTo(c.getID());
26    }
27
28    @Override
29    public String toString() {
30        return "Customer [ id=" + id + ", name=" + name + " ]" ;
31    }
32 }
```

Create a class Customer

PriorityQueue Example2

```
1 import java.util.*;
2
3 public class PriorityQueue2 {
4     public static void main(String[] args) {
5         PriorityQueue<Customer> customerQueue
6             = new PriorityQueue<>(Collections.reverseOrder());
7
8         customerQueue.add(new Customer(3, "Donald" ));
9         customerQueue.add(new Customer(1, "Chong" ));
10        customerQueue.add(new Customer(2, "Ali" ));
11        customerQueue.add(new Customer(4, "Bala" ));
12
13        Customer c = customerQueue.peek();
14        if (c!=null) {
15            System.out.println(c.getName() + " is in queue");
16            while ((c = customerQueue.poll())!=null)
17                System.out.println(c);
18        }
19        System.out.println();
20    }
21 }
```

```
Bala is in the queue
Customer [ id=4, name=Bala ]
Customer [ id=3, name=Donald ]
Customer [ id=2, name=Ali ]
Customer [ id=1, name=Chong ]
```

Exercise

- Implement a generic Queue using array
- Implement a generic Queue using ArrayList
- Hints: you can name the class `ArrayQueue<E>` and provide the implementation for the following methods:
 - `public ArrayQueue()`
 - `Public ArrayQueue(int initial)`
 - `public void enqueue(E e)`
 - `public E dequeue()`
 - `public E getElement()`
 - `public boolean isEmpty()`
 - `public int size()`
 - `public void resize()`

Reference

- Chapter 19 and 24, Liang, Introduction to Java Programming, 10th Edition, Global Edition, Pearson, 2015