Data Structures

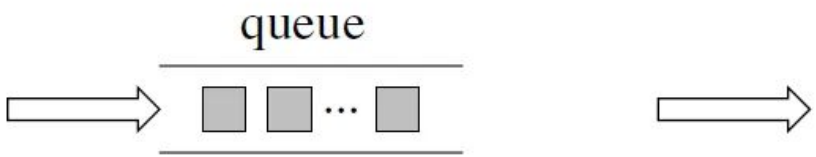
Queue Data Structure

Mostafa S. Ibrahim
Teaching, Training and Coaching since more than a decade!

Artificial Intelligence & Computer Vision Researcher
PhD from Simon Fraser University - Canada
Bachelor / Msc from Cairo University - Egypt
Ex-(Software Engineer / ICPC World Finalist)

What is a queue?

- In English, queue is a **line of items** awaiting their turn.
  - Queue of people in a restaurant waiting their turn
  - Queue of patients in a hospital
  - In customer service, queue of customer calls waiting an employee response
- Let’s say we are in restaurant and there are 5 people awaiting
  - Which one we serve first? The first one must be served first!
  - We call this: **FIFO = First in, First out**



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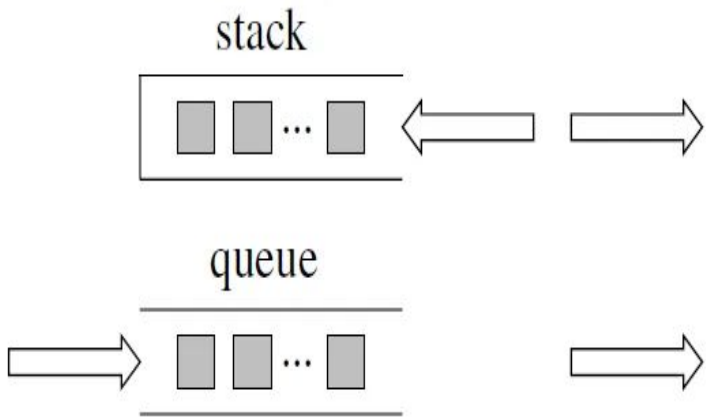
FIFO vs FILO

- Keep in mind this difference in mind between stack and queue processing



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Queue ADT

- We need to design a data structure that follows FIFO
- **enqueue**(value): **Add** in the **end** (**rear**) of the queue
- **dequeue**(): **Delete** from the **front** of the queue
- Useful functionalities:
  - isEmpty(), isFull(), clear(), frontQueue(), rearQueue()
- Any implementation that satisfies this (FIFO) = Queue

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Queue Tracing

- Let’s trace the following operations
- enqueue(5)

Front

5				

Queue Tracing

- Let’s trace the following operations
- enqueue(5)
- enqueue(7)

Front

5	7			

Queue Tracing

- Let’s trace the following operations
- enqueue(5)
- enqueue(7)
- enqueue(8)

Front

5	7	8		

Queue Tracing

- Let’s trace the following operations
- enqueue(5)
- enqueue(7)
- enqueue(8)
- dequeue() ⇒ 5

Front

7	8			

Queue Tracing

- Let’s trace the following operations
- enqueue(5)
- enqueue(7)
- enqueue(8)
- dequeue() ⇒ 5
- enqueue(6)

Front

7	8	6		

Queue Tracing

- Let’s trace the following operations
- enqueue(5)
- enqueue(7)
- enqueue(8)
- dequeue() ⇒ 5
- enqueue(6)
- dequeue() ⇒ 7

Front

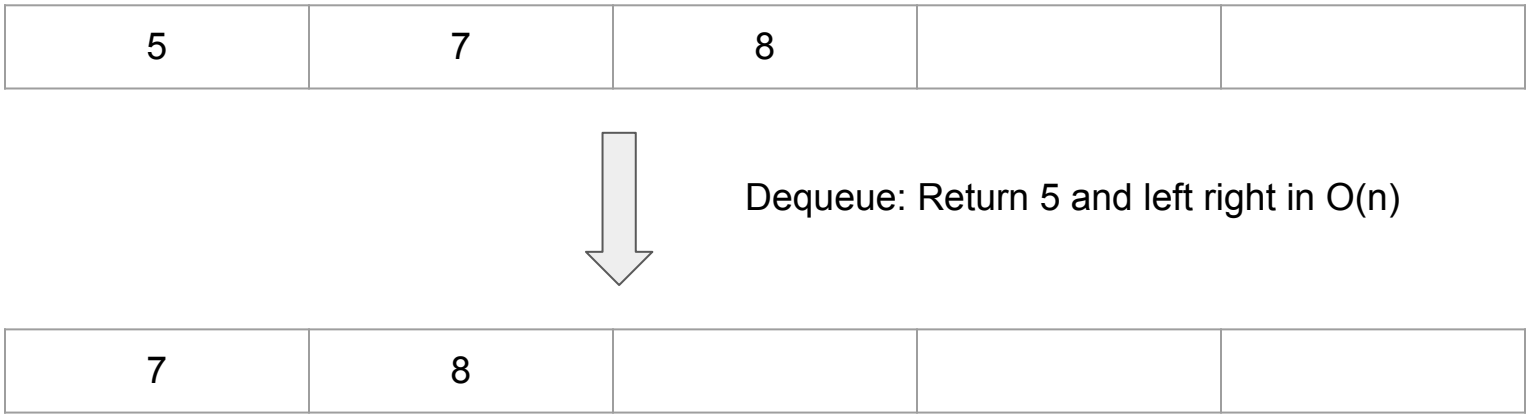
8	6			

Implementation

- Array-based Queue
  - Enqueuing elements is trivial, but all troubles come from dequeuing
  - Let’s see couple of approaches (*direct to implement*)
- Linked-list-based Queue

Array-based: Shift approach

- Assume we added 3 elements so far in the array: {5, 7, 8}
- Now, after we dequeue 5, this index = 0 is empty
- One way is to just shift **left** the whole array ⇒ **O(n) dequeue**!



Array-based: Front-Rear approach

- We will have 2 **indices**: front and rear representing start to end in array
  - When we **enqueue** element we add it in rear
  - When we **dequeue** element we **shift front index** to the right ⇒ O(1)
- Let's add {5, 7, 8}

Array-based: Front-Rear approach

- We will have 2 indices: front and rear representing start to end in array
  - When we enqueue element we add it in rear
  - When we dequeue element we shift front to the right ⇒ **O(1)**
- Dequeue (front++)

Array-based: Front-Rear approach

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  - When we enqueue element we add it in rear
  - When we dequeue element we shift front to the right ⇒ O(1)
- Enqueue 6

Array-based: Front-Rear approach

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  - When we dequeue element we shift front to the right ⇒ O(1)
- Enqueue 9

Array-based: Front-Rear approach

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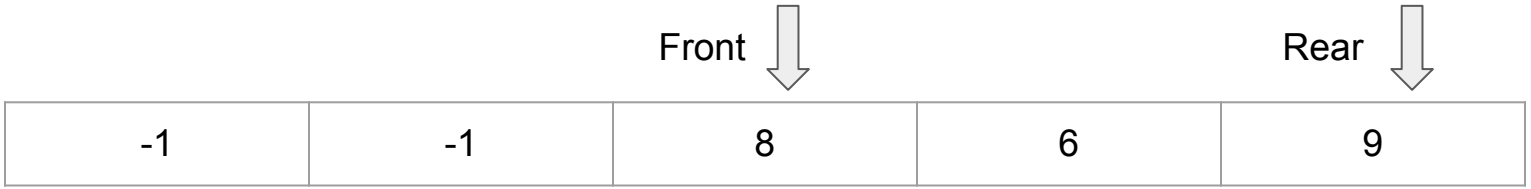
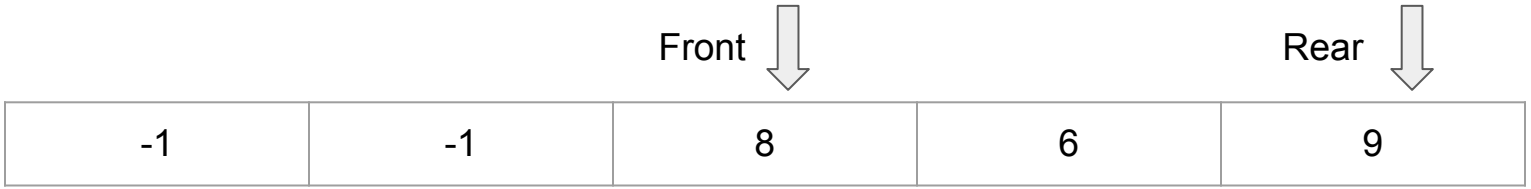
  - When we dequeue element we shift front to the right ⇒ O(1)
- Dequeue ⇒ 7



Array-based: Front-Rear approach

- We will have 2 indices: front and rear representing start to end in array
  - When we enqueue element we add it in rear
  - When we dequeue element we shift front to the right ⇒ O(1)
- Enqueue 3: ERROR Queue is full!
- Wait, but there are slots empty in the begin!
  - This is a critical **drawback** in this approach
  - How to solve? Think for 15 minutes!



"Acquire knowledge and impart it to the people."

"Seek knowledge from the Cradle to the Grave."