TECHNO INDIA UNIVERSITY
WESTBENGAL

Data Structures & Algorithms
(PCC-CS 301)

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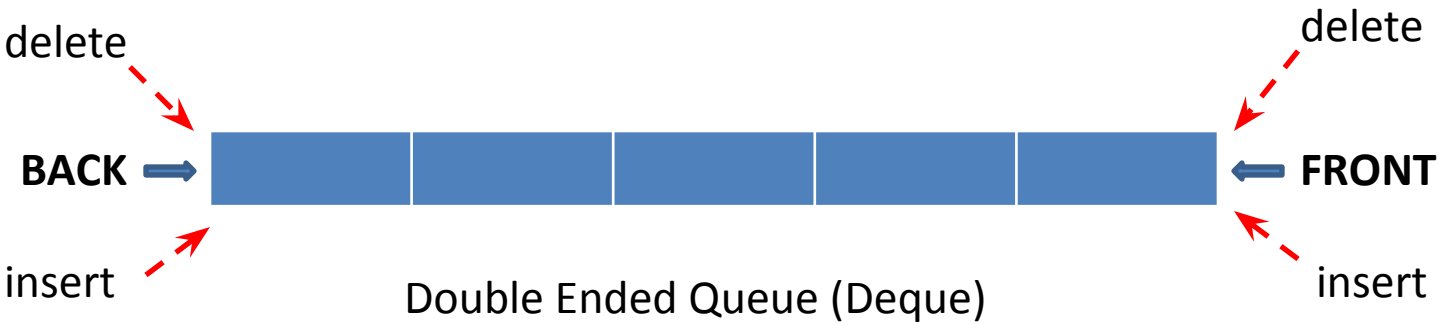
Topics Covered

1. Linear Data Structure
    a. Double Ended Queue (Deque)
    b. Stack using Deque
    c. Queue using Deque

Double Ended Queue

Deck of playing cards

A card can be inserted or taken from the top as well as from the bottom of the deck



Double Ended Queue (Deque)

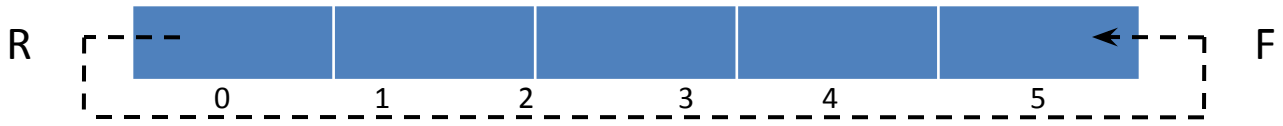
[pronounced as Deck]

Queue

- Double Ended Queue (Deque)
  - Properties
    - Deque is a generalized version of Queue data structures
    - An element can be inserted from both end of the queue
    - An element can be deleted from both end of the queue
    - It does not specifically maintain FIFO concept
    - The concept of Stack and Queue both can be represented through this single Deque data structure
      - Stack can be represented by restricting data insertion and deletion at back end only
      - Queue can be represented by restricting data insertion at back end only and deletion from front end only

Double Ended Queue

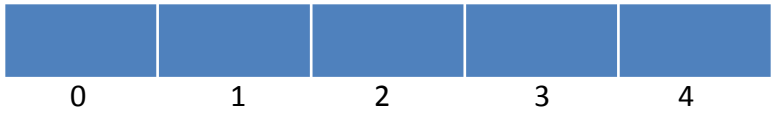
- Deque
  - Representation
    - Using array
    - Using linked-list (to be discussed later)
  - Array representation
    - Using circular array



Double Ended Queue

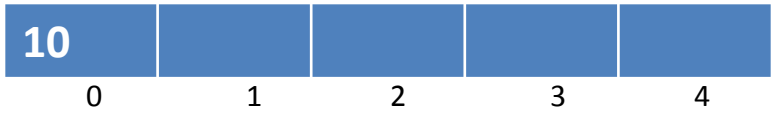
- Double Ended Queue
  - Different cases

F=R=null



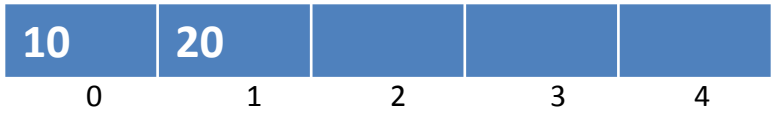
Empty Queue

F=R=0



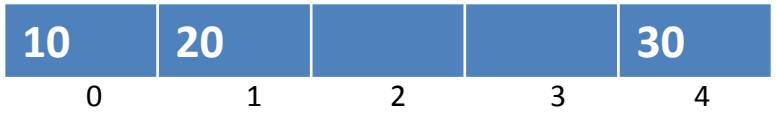
Insert 1st element

F=0 , R=1



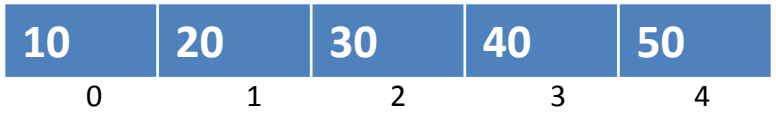
Insert at back

F=4 , R=1



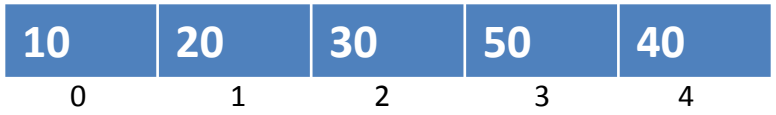
Insert at front

F=0 , R=4



Queue Overflow

F=3 , R=2



Queue Overflow

Double Ended Queue

- Double Ended Queue
  - Operations
    - ENQUEUE (data insertion into queue)
      - Insert at Front
      - Insert at Back
    - DEQUEUE (data deletion from queue)
      - Delete from Front
      - Delete from Back

    Primary operation

    - Display (showing element of queue)
    - QueueSize (returns the total element)
    - IsFullQueue (checks if Queue is overflow)
    - IsEmptyQueue (checks if Queue is underflow)

    Auxiliary operation

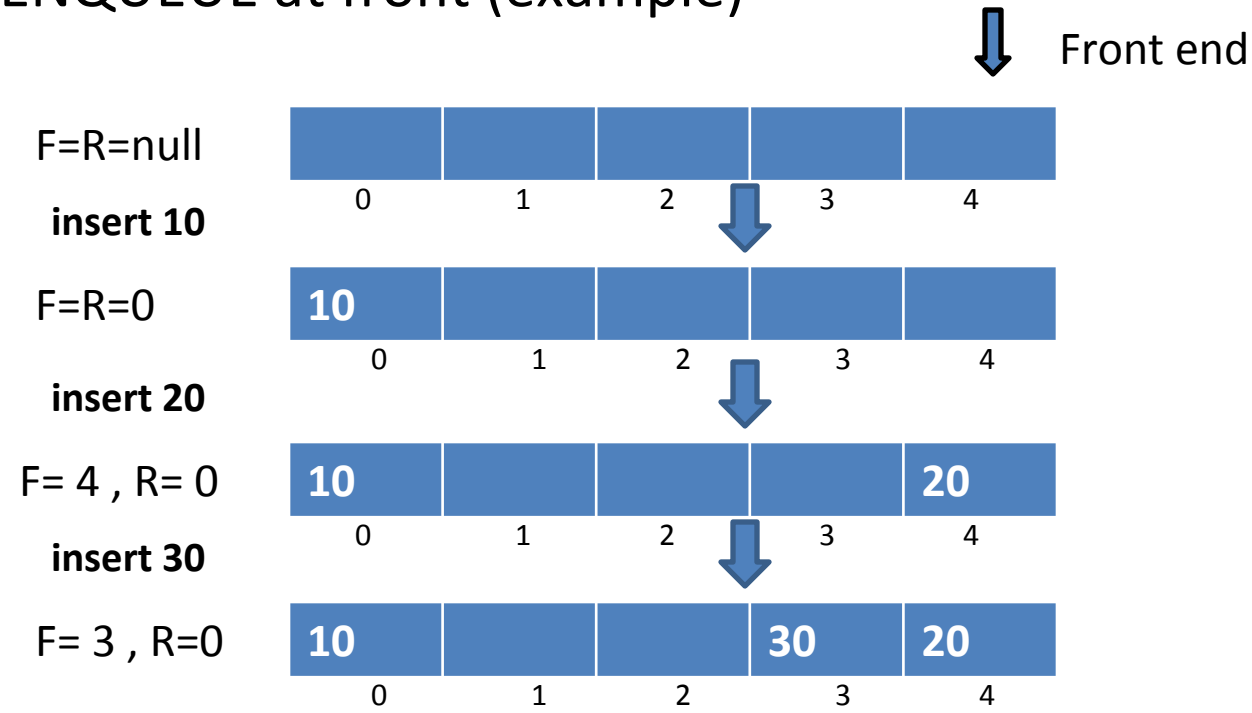
Double Ended Queue

- Operation
  - ENQUEUE
    - Insert element at front

```
void ENQUEUE(data)
{
 if  IsFullQueue = TRUE
    print  Q is full
 else
    if   IsEmptyQueue = TRUE
        F := 0 and R:= 0
    else
       if F = 0
         F:= Max_Size
       else
         F:=F-1
    Q(F) := data
}
```

Double Ended Queue

- Operation
  - ENQUEUE at front (example)



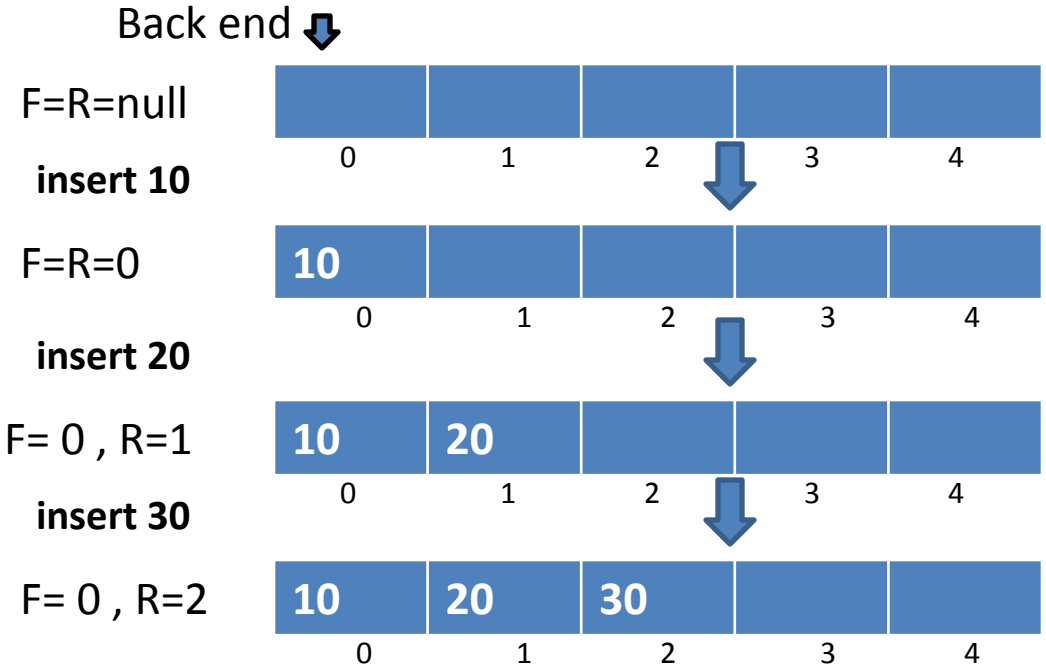
Double Ended Queue

- Operation
  - ENQUEUE
    - Insert element at back

```
void ENQUEUE(data)
{
 if  IsFullQueue = TRUE
    print  Q is full
 else
    if   IsEmptyQueue = TRUE
        F := 0 and R:= 0
    else
       R:= R+1
    Q(R) := data
}
```

Double Ended Queue

- Operation
  - ENQUEUE at back (example)



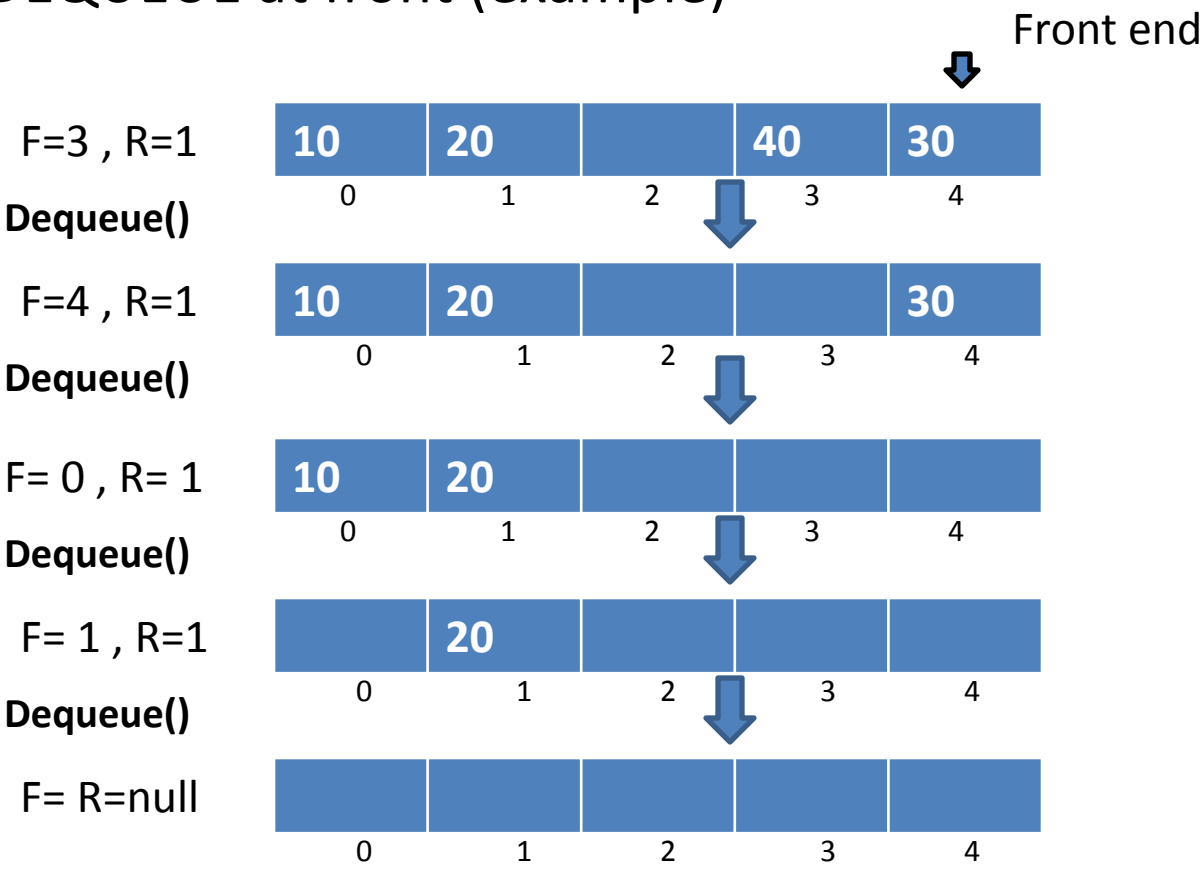
Double Ended Queue

- Operation
  - DEQUEUE
    - Delete element from front

```
int DEQUEUE()
{
 if  IsEmptyQueue = TRUE
   return NULL
 else
    data := Q(F)
    if   F = R
      F := null and R:= null
    else
       if  F = Max_Size
          F := 0
       else
          F := F+1
   return data
}
```

Double Ended Queue

- Operation
  - DEQUEUE at front (example)



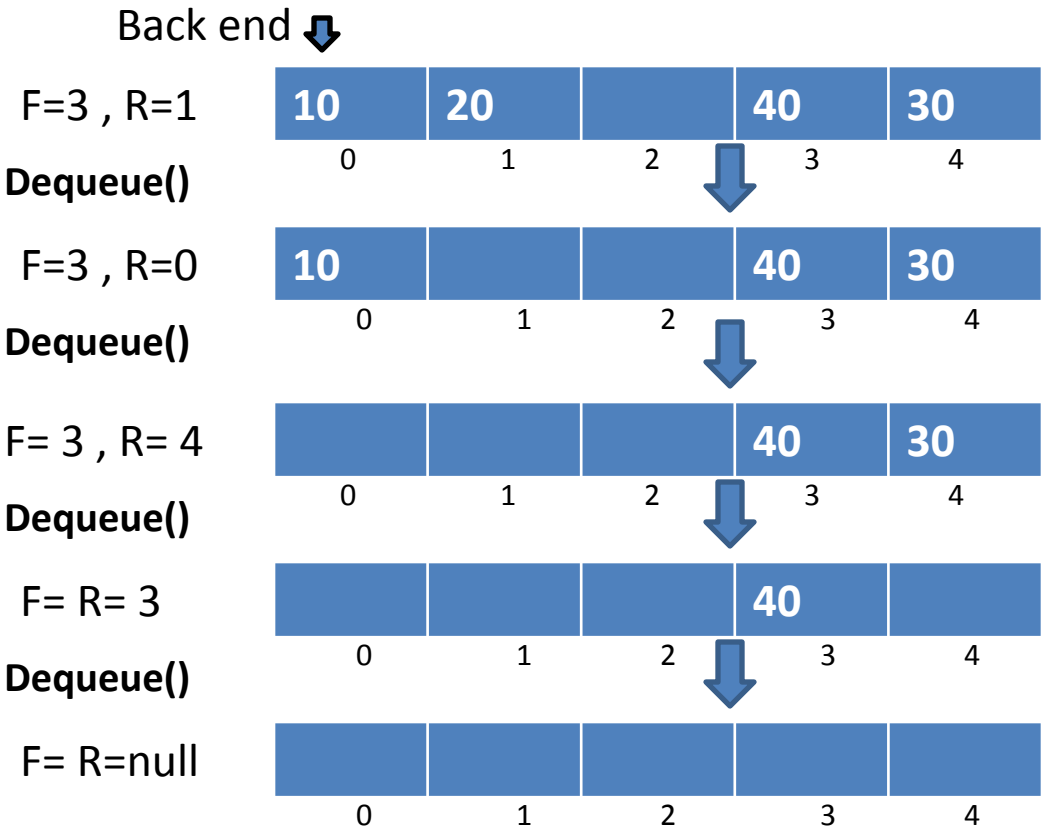
Double Ended Queue

- Operation
  - DEQUEUE
    - Delete element from back

```
int DEQUEUE()
{
 if  IsEmptyQueue = TRUE
   return NULL
 else
    data := Q(R)
    if   F = R
      F := null and R:= null
    else
        if  R = 0
           R := Max_Size
        else
           R := R - 1
   return data
}
```

Double Ended Queue

- Operation
  - DEQUEUE at back (example)



Double Ended Queue

- Operation
  - Display
    - The queue can be displayed through an auxiliary pointer without shifting FRONT or REAR

```
void Display()
{
  if  IsEmptyQueue = TRUE
    print  Q is empty
  else
     for i= F to R
        print  Q(i)
}
```

Double Ended Queue

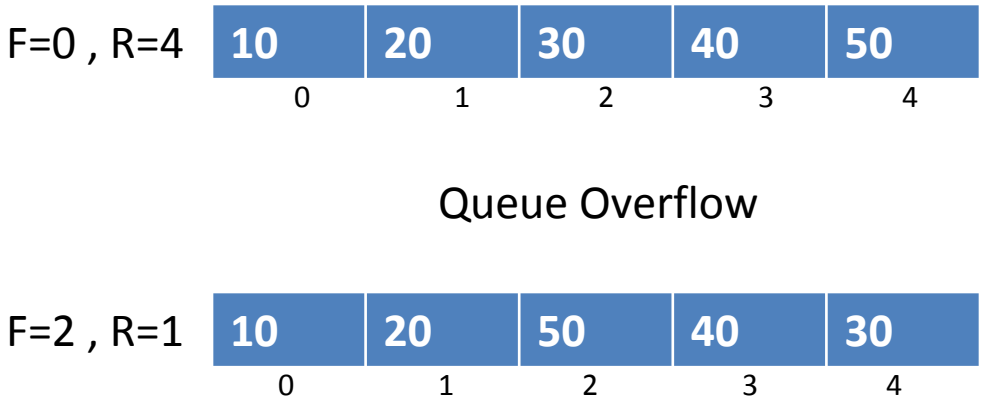
- Operation
  - QueueSize
    - This function returns the counting of elements present in the current queue

```
int QueueSize()
{
  if  F = null and R = NULL
     return 0
  else
     for i = F to R
        count := count +1
     return count
}
```

Double Ended Queue

- Operation
  - IsFullQueue
    - This function checks whether the Queue is full or not
    - We cannot insert data into Queue if it is full

```
Boolean IsFullQueue()
{
 if  (F=0 and R = Max_Size) or
      (F = R+1)
   return TRUE
 else
   return FALSE
}
```



Double Ended Queue

- Operation
  - IsEmptyQueue
    - This function checks whether the Queue is empty or not
    - We cannot delete or display the Queue if it is empty

```
Boolean IsEmptyQueue()
{
  if  F = null and R = null
    return TRUE
  else
    return FALSE
}
```

Double Ended Queue

- Operation: complexity

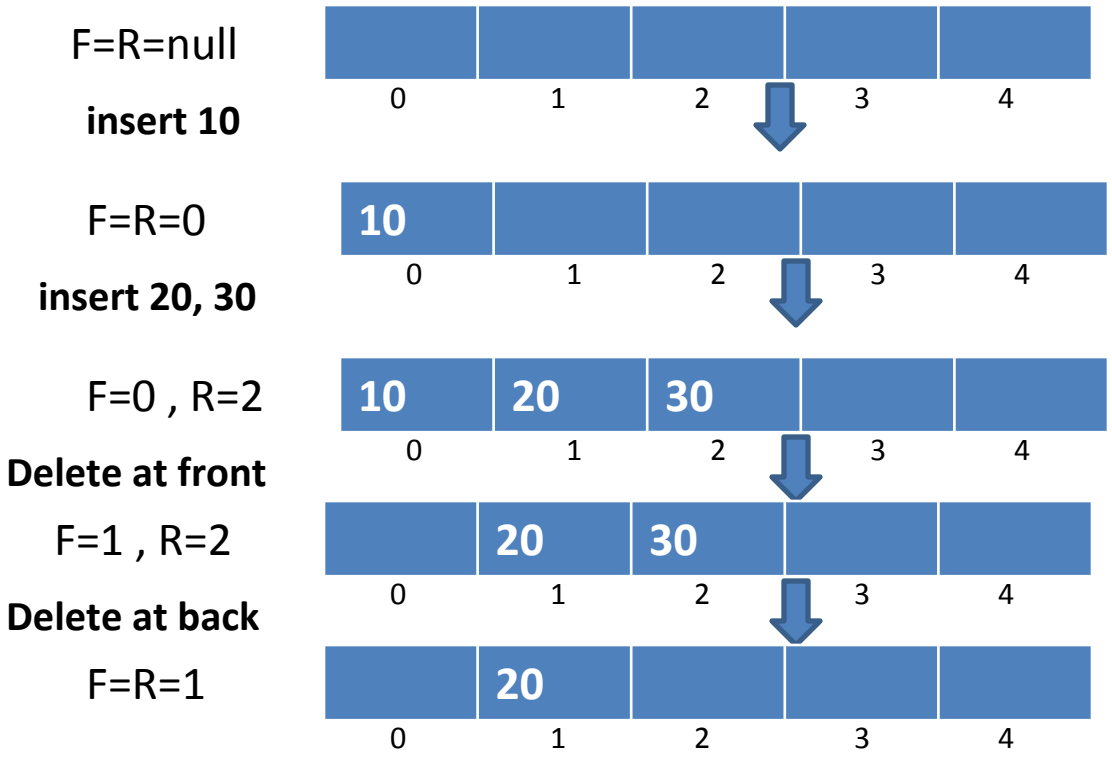
Operation	Time Complexity
Enqueue()	O(1)
DeQueue()	O(1)
Display()	O(n)
QueueSize()	O(n)
IsFullQueue()	O(1)
IsEmptyQueue()	O(1)

Double Ended Queue

- Variants
  - Input Restricted Deque
    - Data can be inserted at one end but deletion can be made from both the ends
      - Insert data at front or
      - Insert data at back
  - Output Restricted Deque
    - Data can be inserted at both ends but deletion ca be made from one end only
      - Delete data from front or
      - Delete data from back

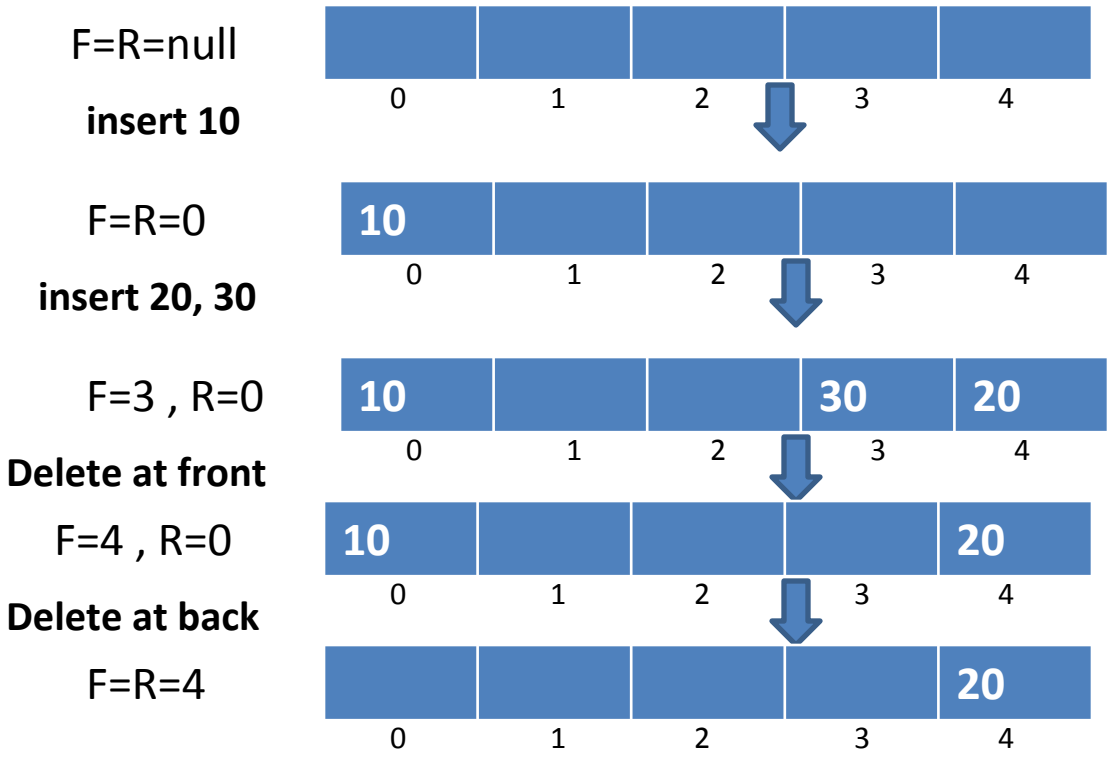
Double Ended Queue

- Input restricted Deque
  - Input restricted at **front** end



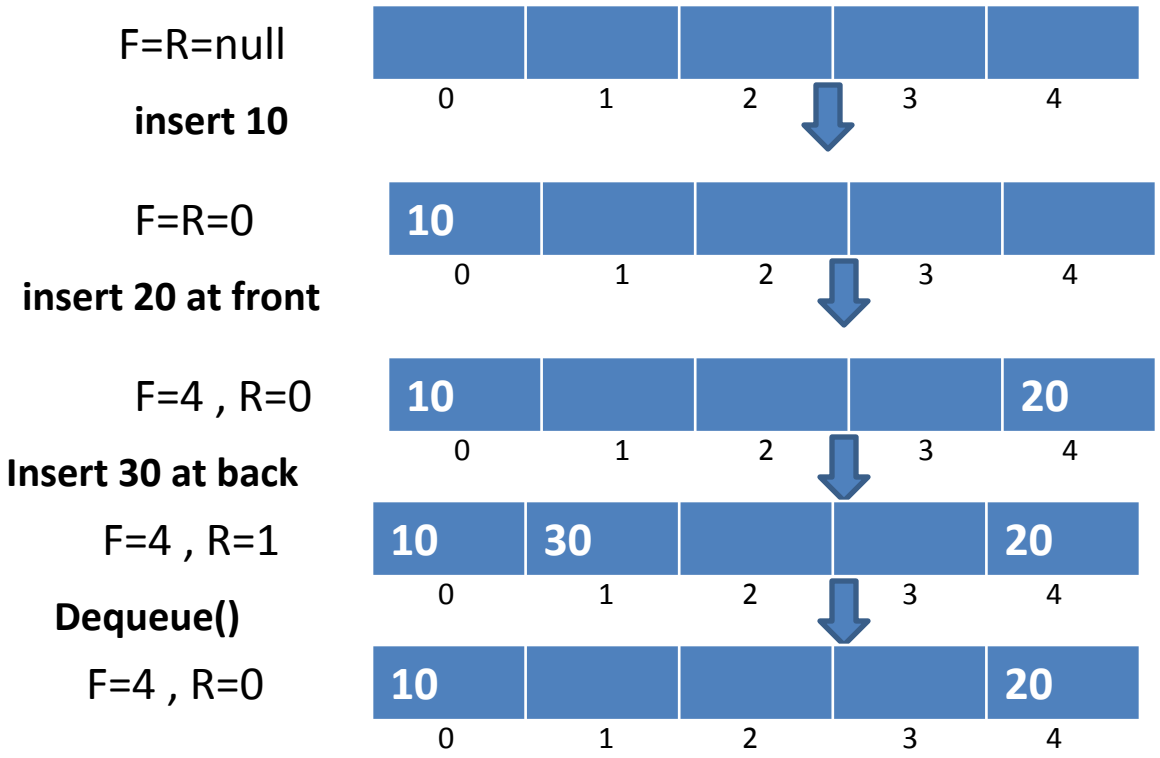
Double Ended Queue

- Input restricted Deque
  - Input restricted at **back** end



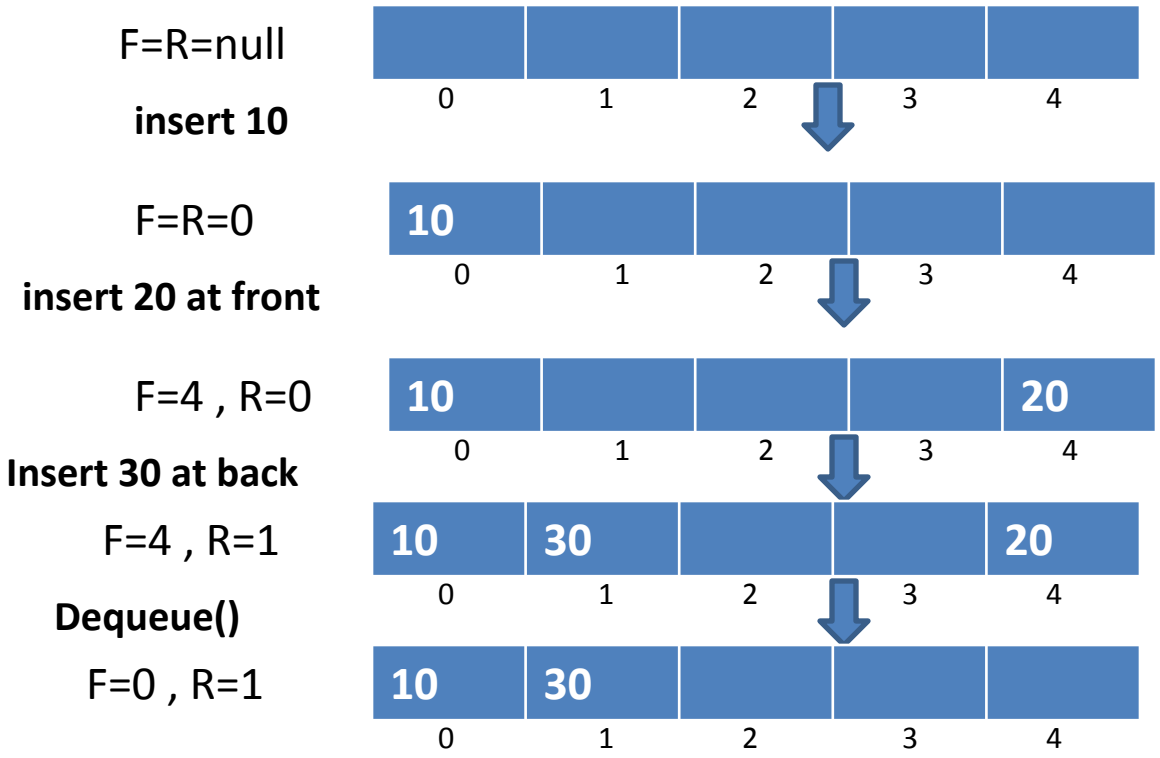
Double Ended Queue

- Output restricted Deque
  - Output restricted at **front** end



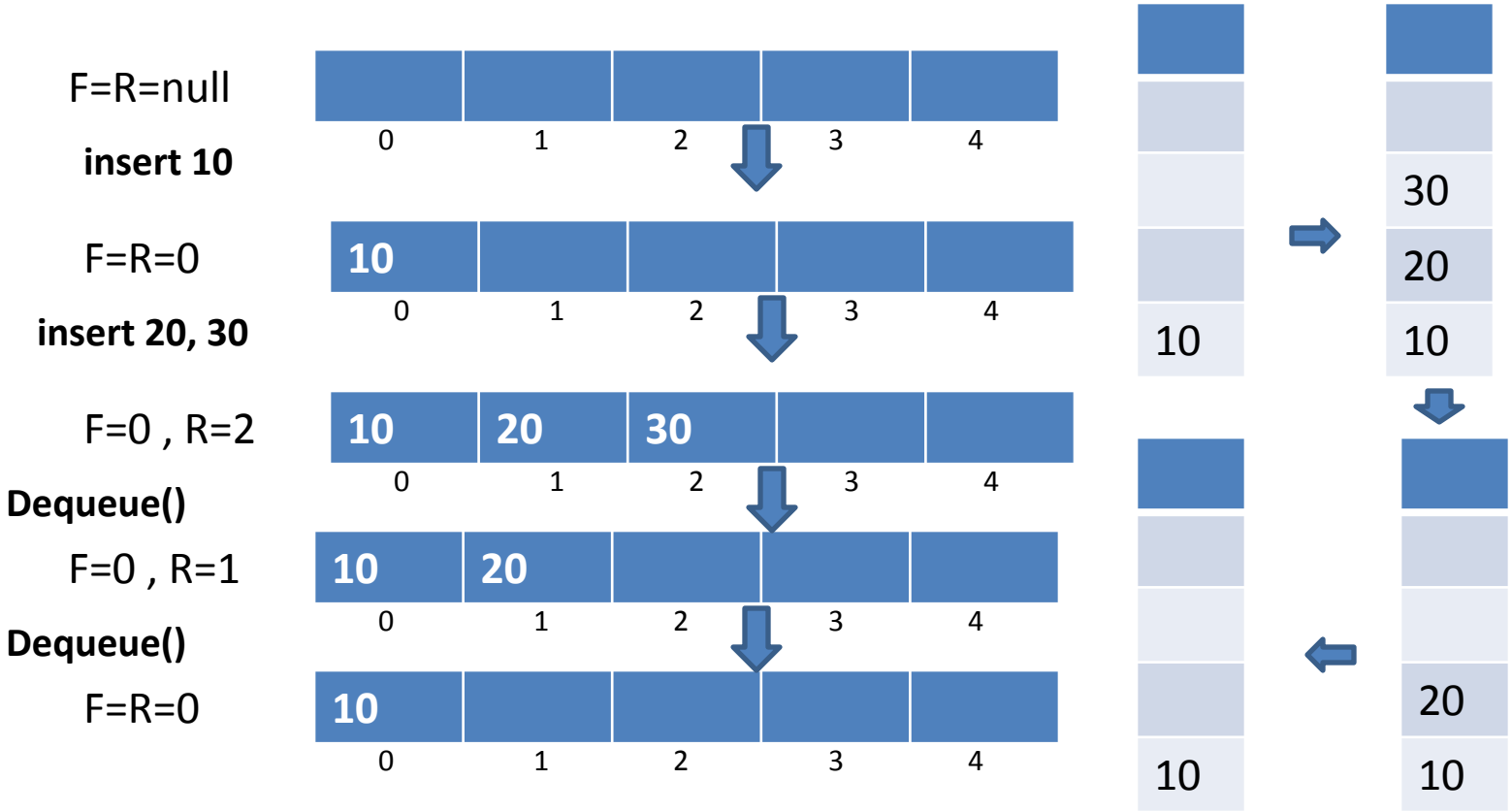
Double Ended Queue

- Output restricted Deque
  - Output restricted at **back** end



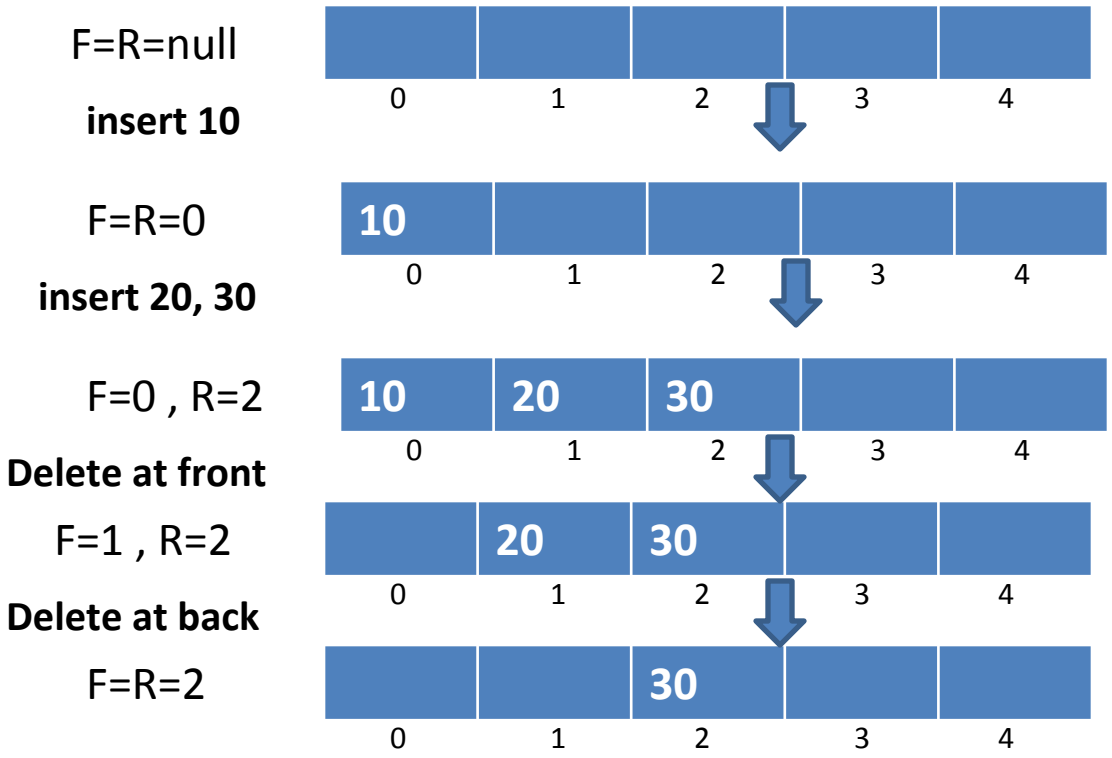
Double Ended Queue

- Deque as Stack
  - Insertion at **back** and deletion **from** back



Double Ended Queue

- Deque as Queue (simple queue)
  - Insertion at **back** and deletion from **front**



Queries?