



Queue Data Structure



Problem: Tickets Counter

You have to implement a **menu based program** in which you have the option to add a customer, give ticket to a customer and view the customers in the line.

```
----Tickets Counter----  
1. Add Customer  
2. Give Ticket to the customer  
3. View all the Customers waiting in the Line  
4. Exit  
Enter Option:
```

Problem: Tickets Counter

If you have added 3 customers in the line and you have given ticket to only the first customer then after pressing option 3 output will be:

```
----Tickets Counter----  
1. Add Customer  
2. Give Ticket to the customer  
3. View all the Customers waiting in the Line  
4. Exit  
Enter Option: 3  
Customers Line : 2      3  
Press any Key to continue
```

Problem: Tickets Counter

How can we implement that?



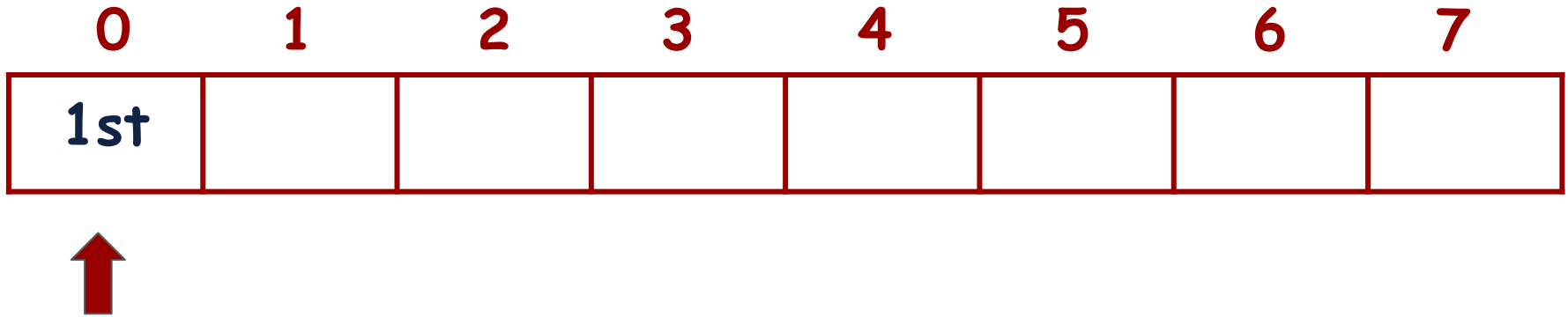
Problem: Tickets Counter

There can be **more than one customers** therefore we have to store the information of the customers in the **Array**.

0	1	2	3	4	5	6	7

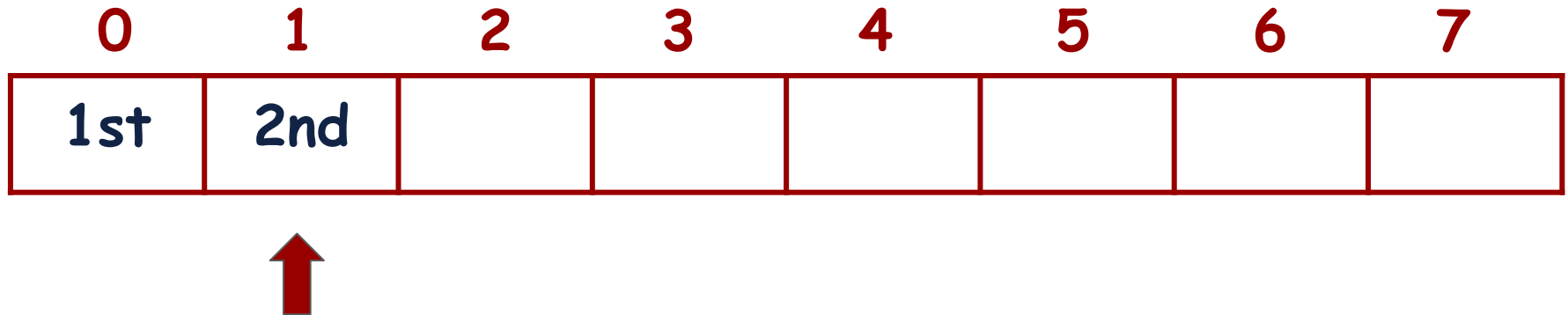
Problem: Tickets Counter

If first customer comes then we add it into the array.



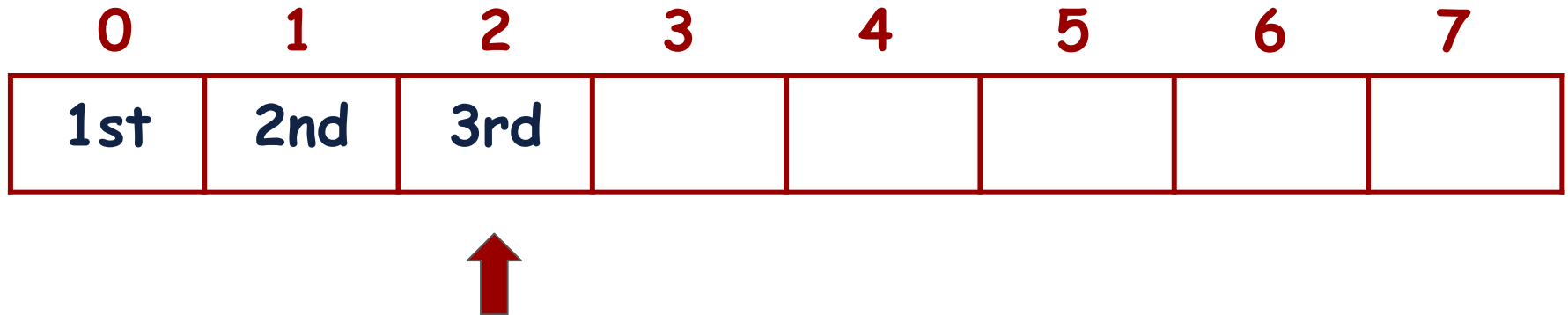
Problem: Tickets Counter

If second customer comes then we add it at the end of the array.



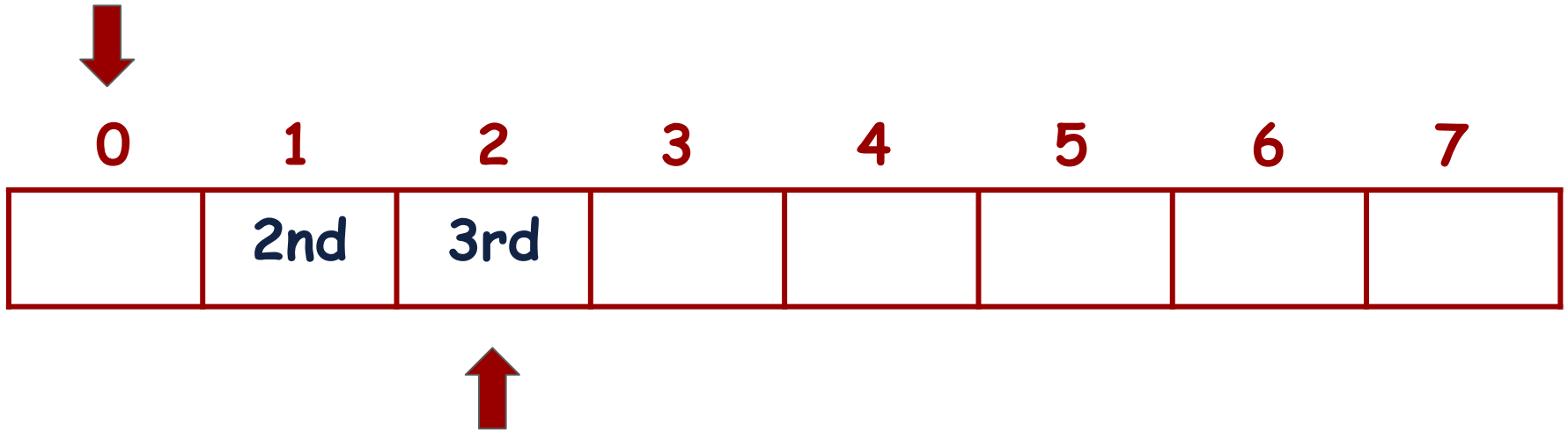
Problem: Tickets Counter

If third customer comes then we add it at the end of the array.



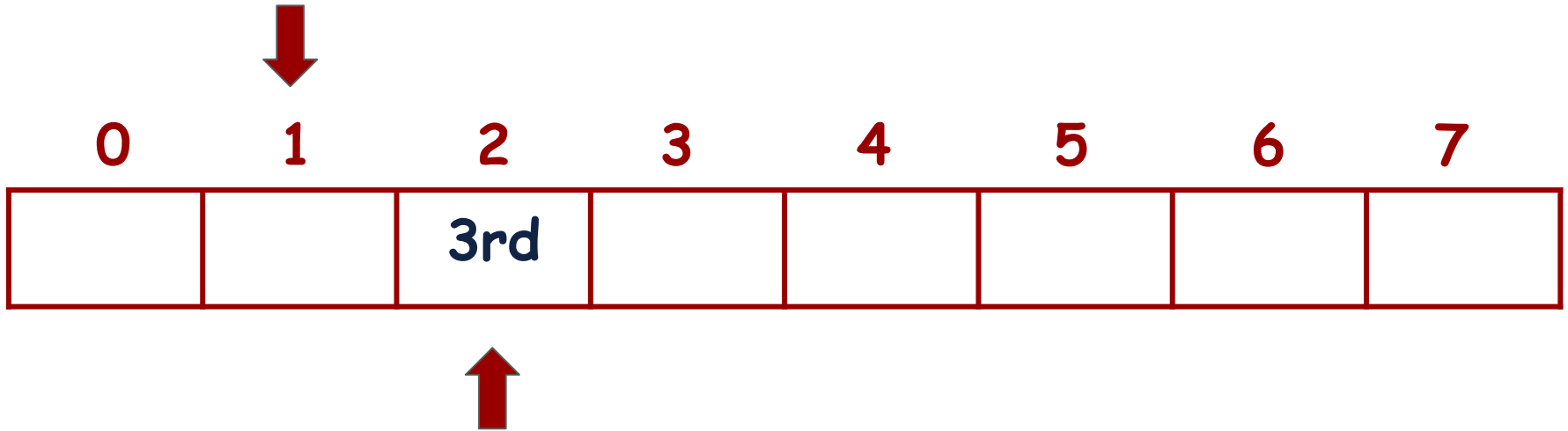
Problem: Tickets Counter

If we give ticket to one customer then we remove the first customer from the start of the array.



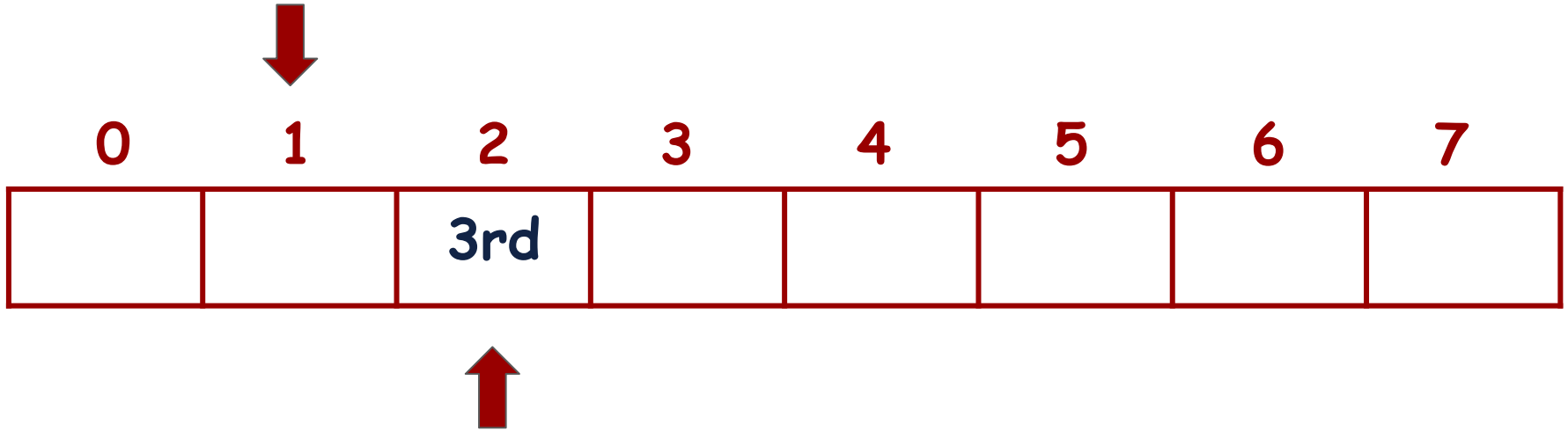
Problem: Tickets Counter

If we give ticket to another customer then we remove the second customer from the start of the array.



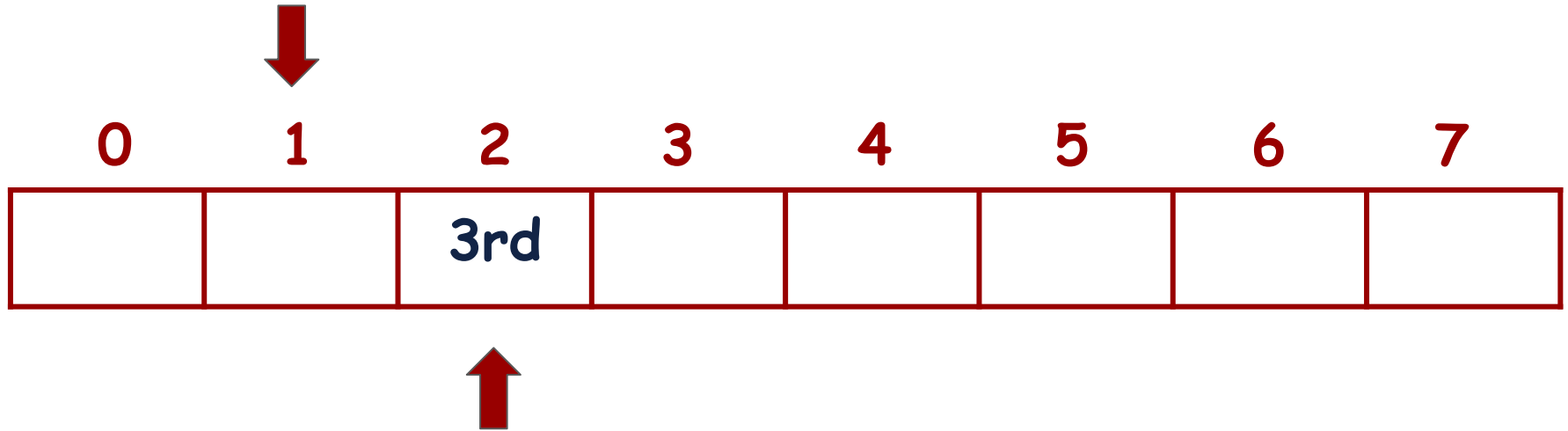
Problem: Tickets Counter

The constraints on the array are that we are adding the new customer at the **end of the array** and we are removing the customers from the **start of the array**.



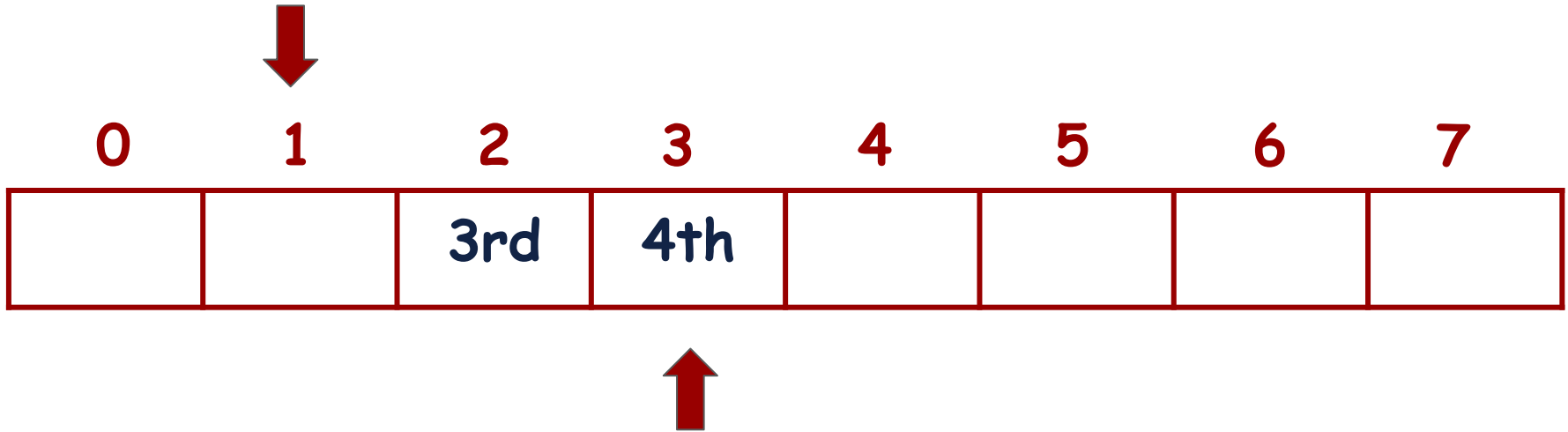
Queue

We consider this a **new Data Structure** and call it **Queue**.



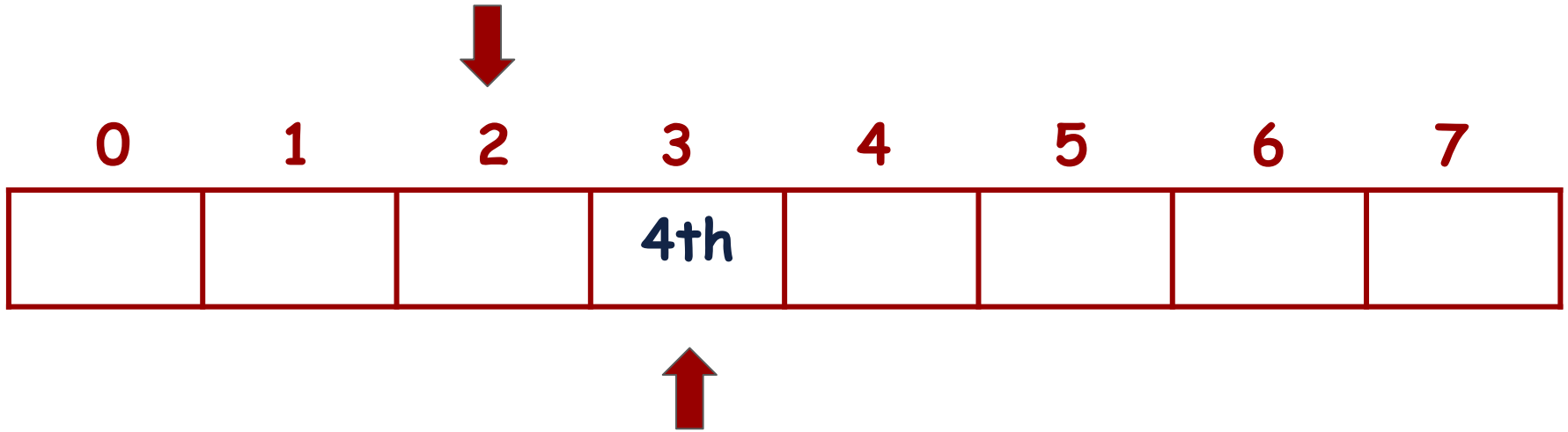
Queue: Rear or Tail

We **insert** new elements at the end of the Queue called as **Rear or Tail**.

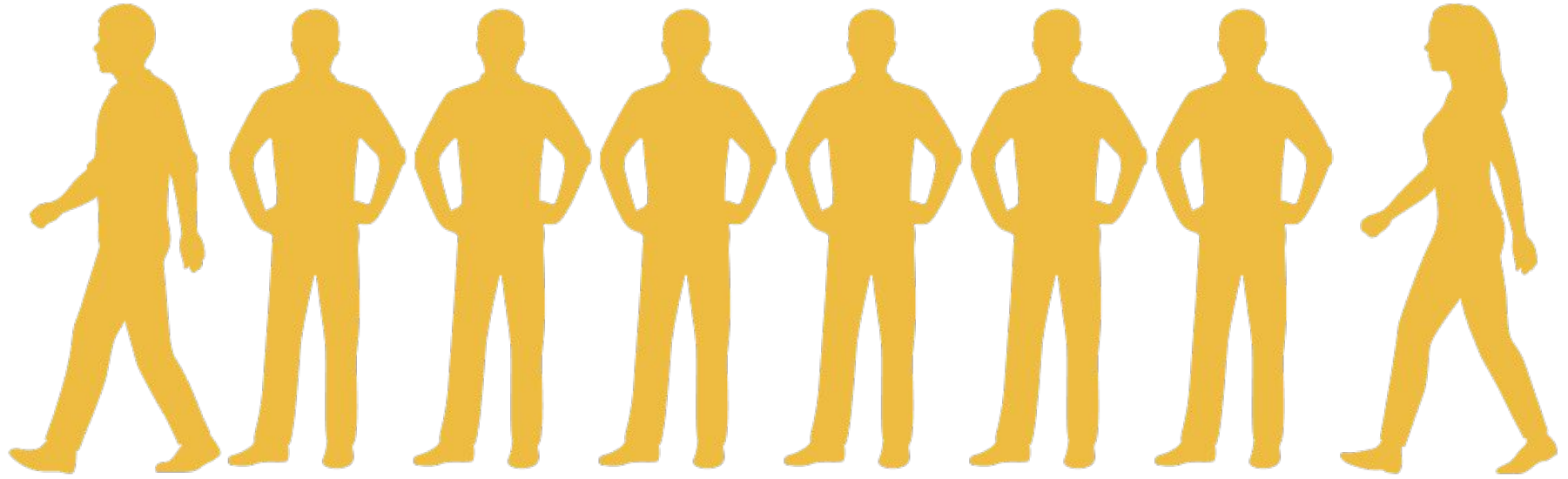


Queue: Front or Head

We **delete** the elements at the start of the Queue called as **Front or Head**.



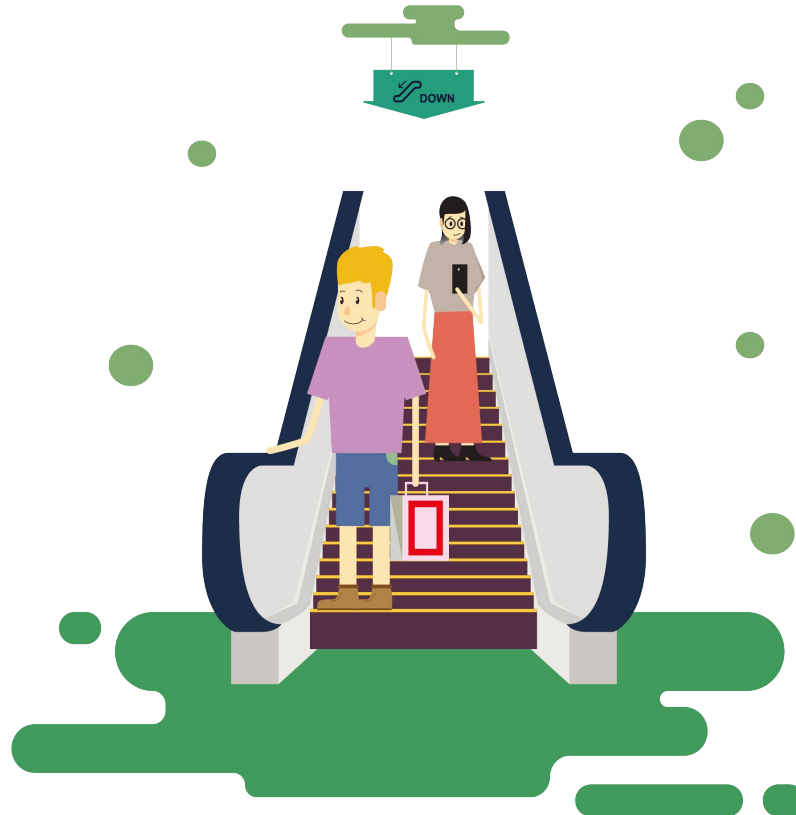
Queue: Real Life Examples



Person leaving
the queue

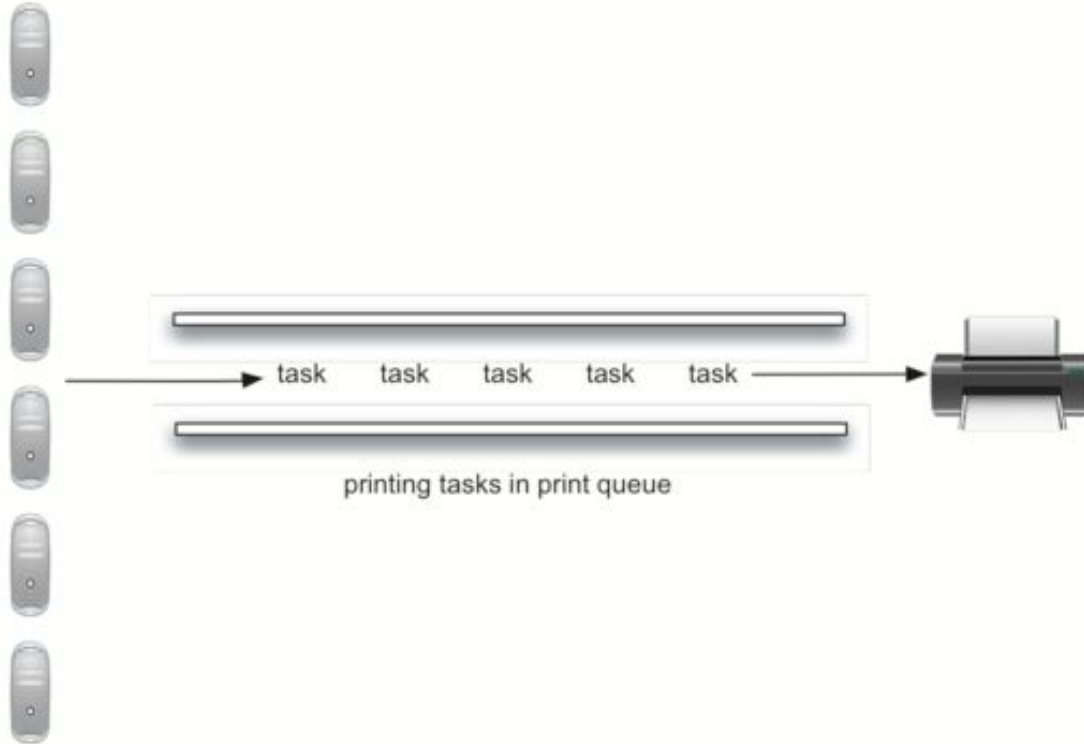
Person entering
the queue

Queue: Real Life Examples



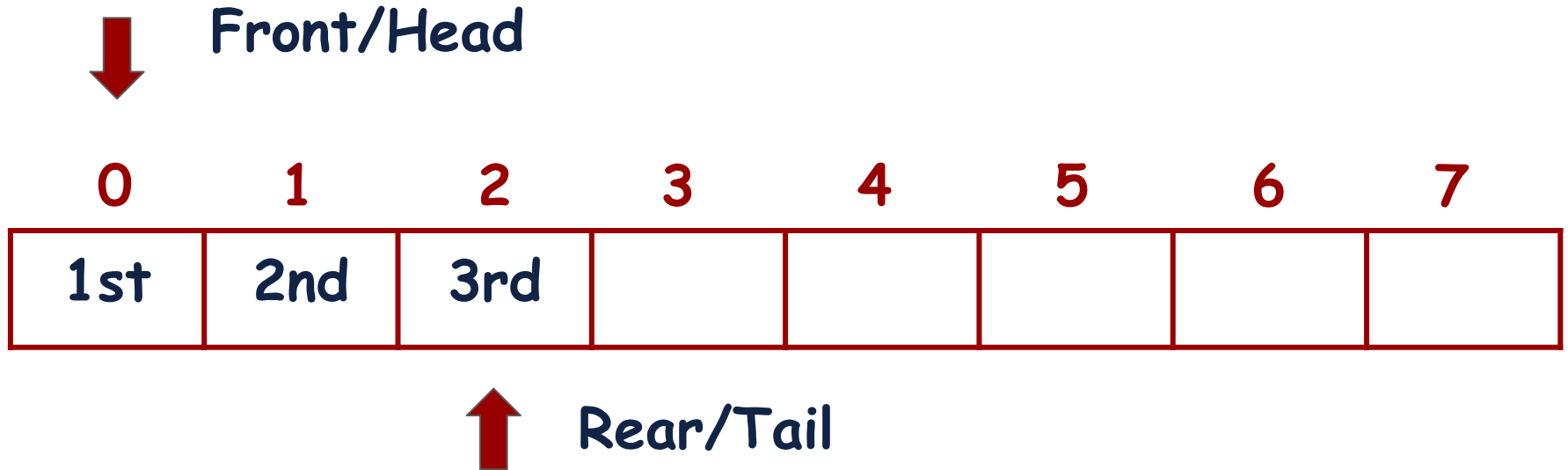
Queue: Real Life Examples

Lab Computers



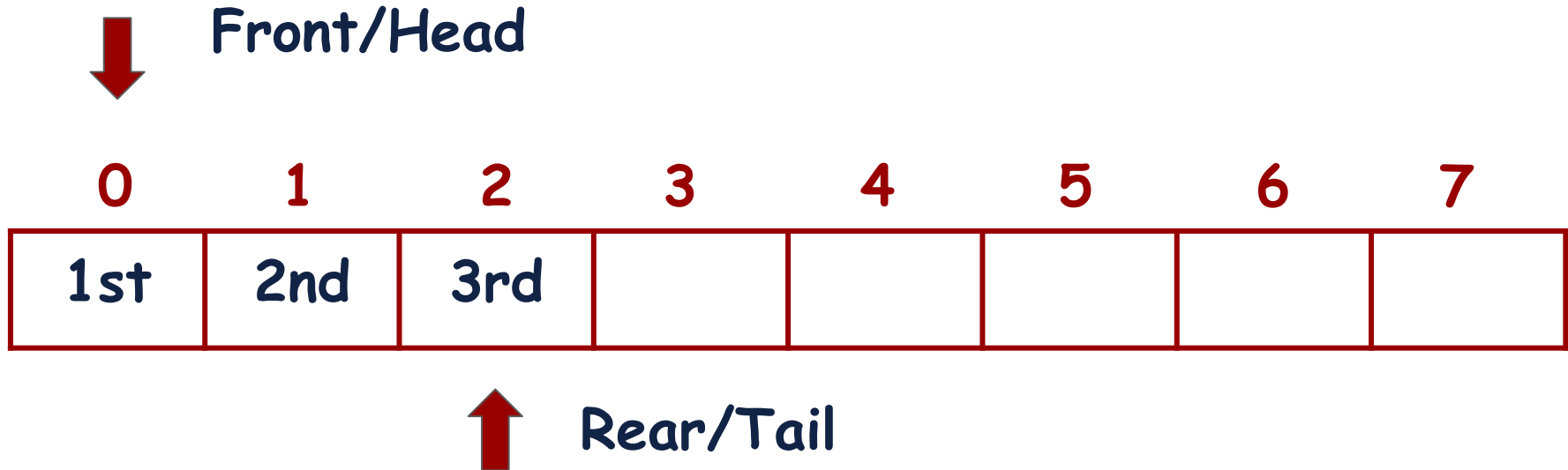
Queue: FIFO

Queue follows **FIFO** (First In First Out) principle.



Queue: Operations on Queue

We have to add the elements at the **Tail** of the Queue and we have to remove the elements at the **Head** of the Queue.



Queue: Operations on Queue

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In Technical Terms:

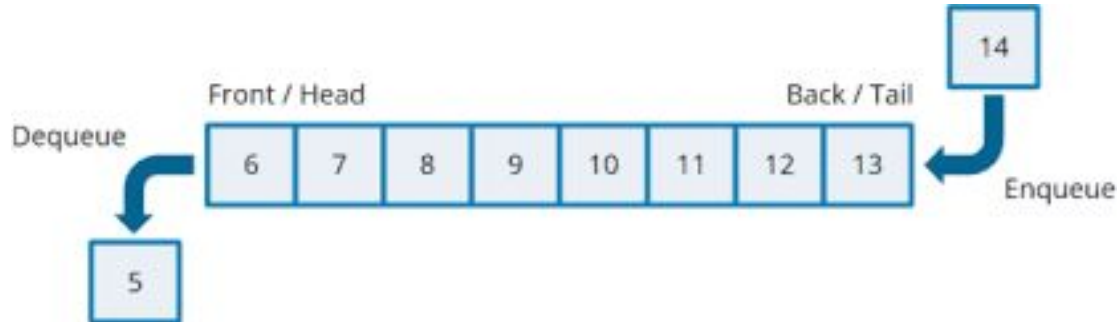
- Add == Enqueue
- Delete == Dequeue

Queue: Operations on Queue

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In Technical Terms:

- Add == Enqueue
- Delete == Dequeue



Queue: Operations on Queue

We can now apply other operations of the Queue as well

- View whether the Queue is empty or not
- View all the available elements of the Queue



Queue: Implementation using Array

Make a **Class** named Queue and add Enqueue, Dequeue, isEmpty and View functions.

Queue: Implementation using Array

```
const int MAX_SIZE = 10;
class Queue
{
    int myqueue[MAX_SIZE], front, rear;

public:
    Queue()
    {
        front = -1;
        rear = -1;
    }
}
```

```
bool isFull()
{
    if (rear == MAX_SIZE - 1)
    {
        return true;
    }
    return false;
}

bool isEmpty()
{
    if (front == -1)
        return true;
    else
        return false;
}
```


Queue: Implementation using Array

```
bool enqueue(int value)
{
    if (isFull())
    {
        cout << "Queue is full!!";
        cout << endl;
        return false;
    }
    else
    {
        if (isEmpty())
        {
            front = 0;
        }
        rear = rear + 1;
        myqueue[rear] = value;
        return true;
    }
}
```

```
int dequeue()
{
    int value;
    if (isEmpty())
    {
        cout << "Line is empty!!" << endl;
        return -1;
    }
    else
    {
        value = myqueue[front];
        if (front >= rear)
        { // only one element in queue
            front = -1;
            rear = -1;
        }
        else
            front++;
        return value;
    }
}
```

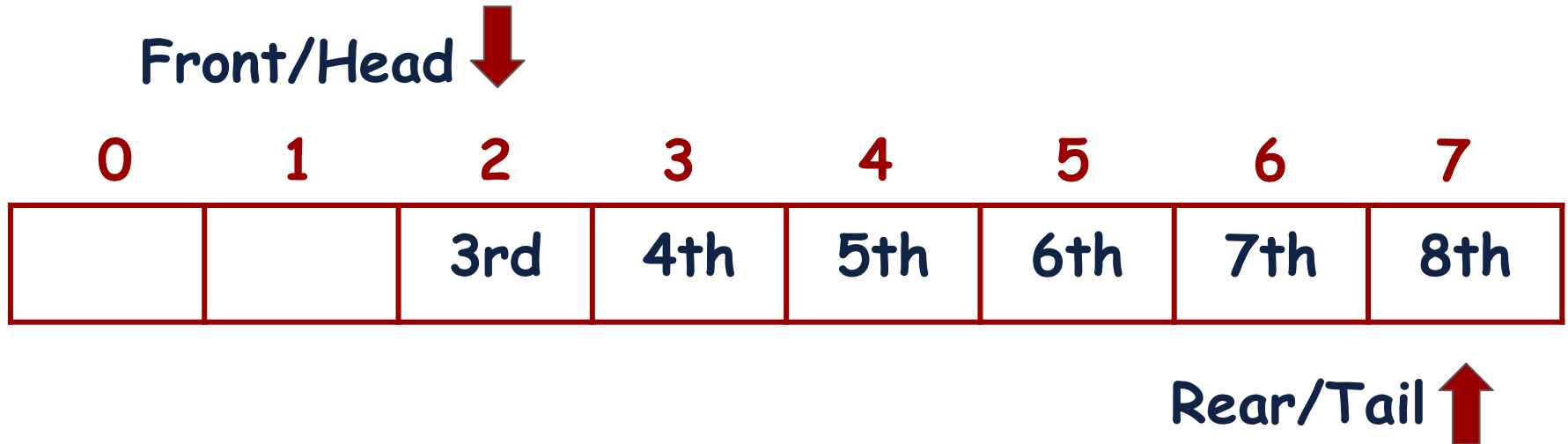
Queue: Implementation using Array

Do you see any problem with the implementation of Queue using Array?



Queue: Implementation using Array

Although there is **space at the start** of the array but when we'll try to add the element, it will give us the **error** that Queue is Full.



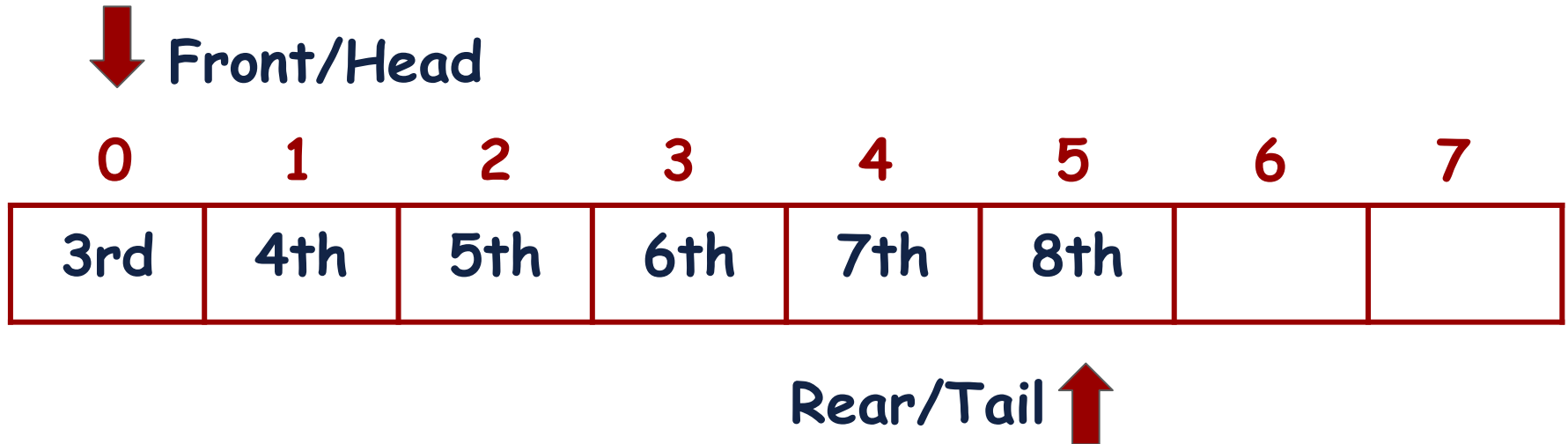
Queue: Implementation using Array

How can we Solve this problem of **Queue is full** issue although there is empty space present in the Array?



Queue: Implementation using Array

Whenever we **delete** an element we push all the elements to one previous index and decrement 1 in the rear.



Queue: Implementation using Array

```
int deQueue()
{
    int value;
    if (isEmpty())
    {
        cout << "Queue is empty!!" << endl;
        return -1;
    }
    else
    {
        value = myqueue[front];
        for(int x = 0; x < rear; x++)
        {
            myqueue[x] = myqueue[x+1];
        }
        rear--;
        return value;
    }
}
```

Queue: Implementation using Array

But this solution comes with extra computational cost (i.e., extra **time** will be required).



Queue: Implementation using LinkedList

So why go through all the fuss when we can implement the queue using **LinkedList**.

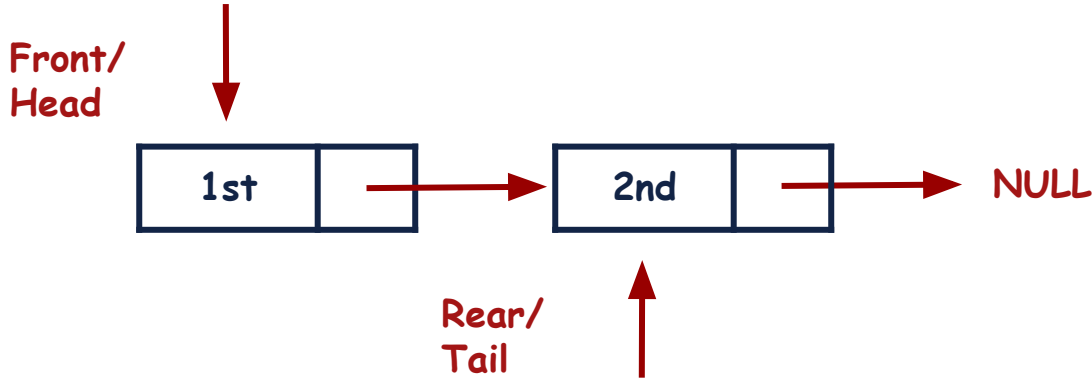


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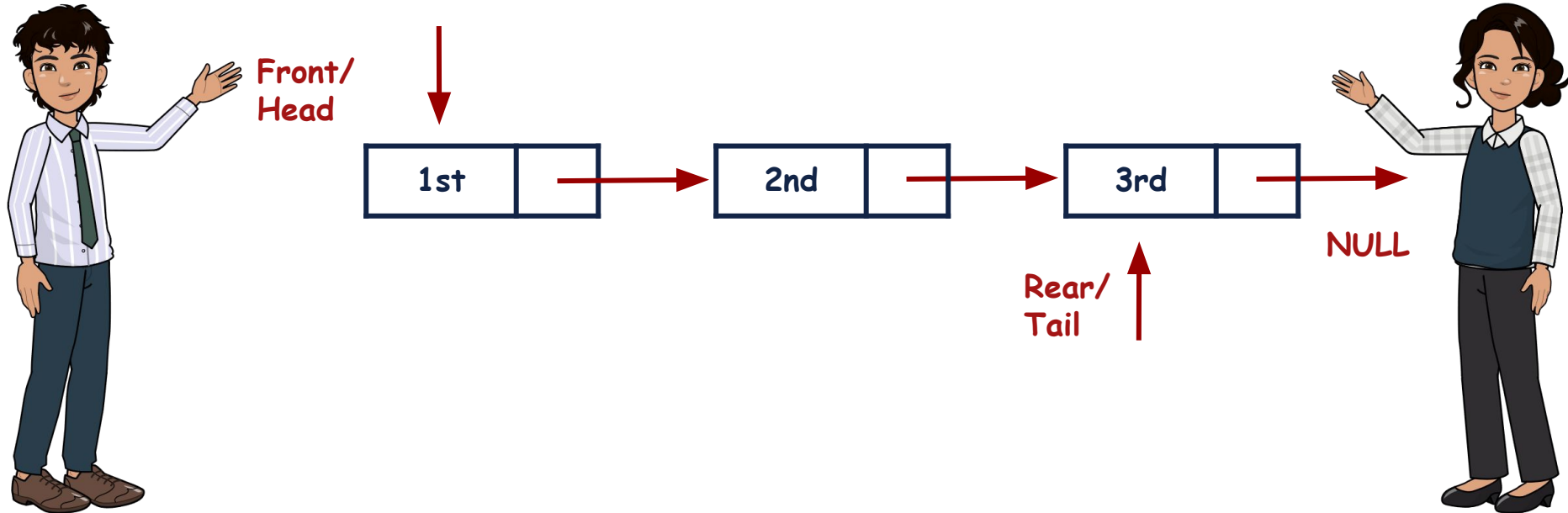
Queue: Implementation using LinkedList

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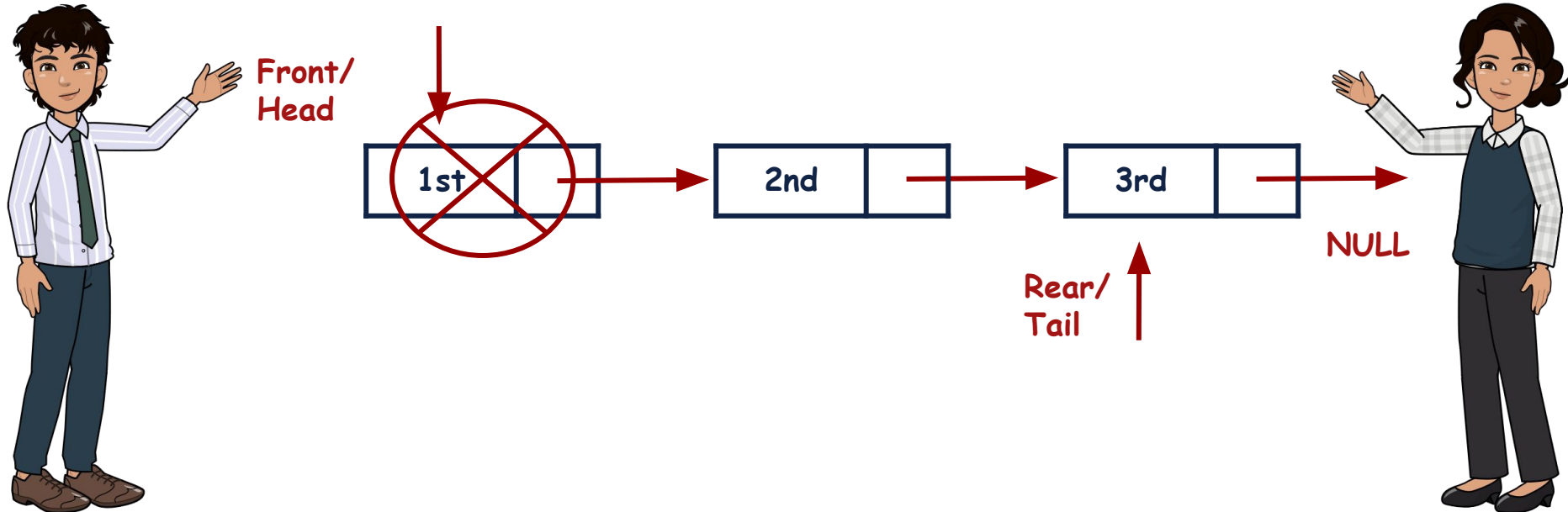
Queue: Implementation using LinkedList

When we **Enqueue** an element we just add at the end of the linkedlist and update the rear pointer.



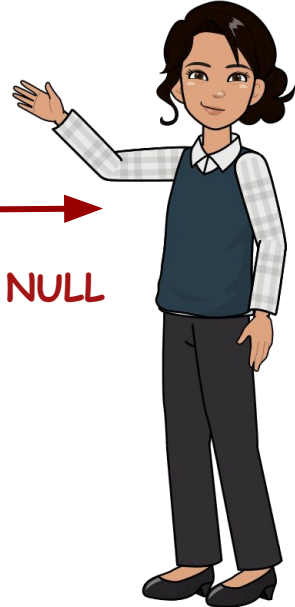
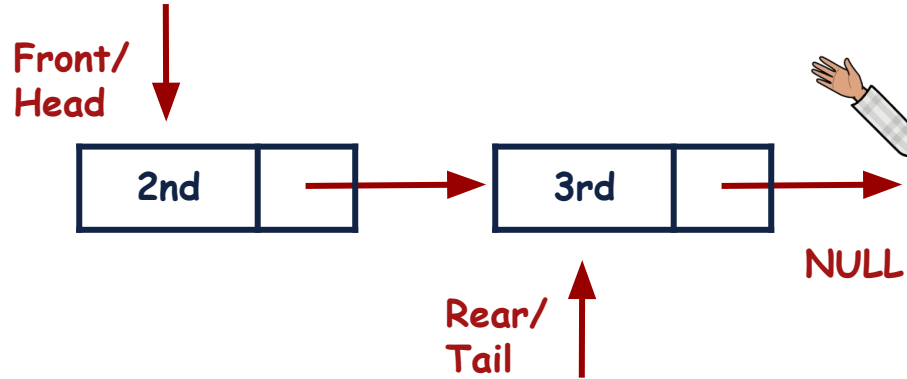
Queue: Implementation using LinkedList

When we **Dequeue**, we just remove the node at the start of the linkedlist and update the front pointer.



Queue: Implementation using LinkedList

When we **Dequeue**, we just remove the node at the start of the linkedlist and update the front pointer.



Queue: Implementation using LinkedList

```
struct node
{
    int data;
    node *next;
};

class Queue
{
    node *front;
    node *rear;

public:
    Queue()
    {
        front = NULL;
        rear = NULL;
    }
}
```

```
bool isEmpty()
{
    if(front == NULL)
    {
        return true;
    }
    return false;
}
```

Queue: Implementation using LinkedList

```
bool enqueue(int item)
{
    node *record = new node();
    record->data = item;
    record->next = NULL;
    if (front == NULL)
    {
        front = record;
        rear = record;
    }
    else
    {
        rear->next = record;
        rear = record;
    }
    return true;
}
```

```
int dequeue()
{
    if (isEmpty())
    {
        cout << "Queue is Empty" << endl;
        return 0;
    }
    else
    {
        node *temp = front;
        int item = temp->data;

        front = front->next;
        delete temp;
        return item;
    }
}
```

Queue: Implementation using LinkedList

```
void displayQueue()
{
    node *temp = front;
    if (isEmpty())
    {
        cout << "Queue is Empty" << endl;
    }
    else
    {
        while (temp != NULL)
        {
            cout << temp->data << "\t";
            temp = temp->next;
        }
        cout << endl;
    }
};
```

Learning Objective

Students should be able to **recognize** real life problems where **queue** data structure is appropriate to solve the problem efficiently.



Self Assessment

There are n people in a line queuing to buy tickets, where the 0^{th} person is at the front of the line and the $(n - 1)^{\text{th}}$ person is at the back of the line.

You are given a 0 -indexed integer array `tickets` of length n where the number of tickets that the i^{th} person would like to buy is `tickets[i]`.

Each person takes exactly 1 second to buy a ticket. A person can only buy 1 ticket at a time and has to go back to the end of the line (which happens instantaneously) in order to buy more tickets. If a person does not have any tickets left to buy, the person will leave the line.

Return the time taken for the person at position k (0 -indexed) to finish buying tickets.

Self Assessment

Example 1:

Input: tickets = [2,3,2], k = 2

Output: 6

Explanation:

- In the first pass, everyone in the line buys a ticket and the line becomes [1, 2, 1].

- In the second pass, everyone in the line buys a ticket and the line becomes [0, 1, 0].

The person at position 2 has successfully bought 2 tickets and it took $3 + 3 = 6$ seconds.

Self Assessment

Example 2:

Input: tickets = [5,1,1,1], k = 0

Output: 8

Explanation:

- In the first pass, everyone in the line buys a ticket and the line becomes [4, 0, 0, 0].
- In the next 4 passes, only the person in position 0 is buying tickets.

The person at position 0 has successfully bought 5 tickets and it took $4 + 1 + 1 + 1 + 1 = 8$ seconds.

Self Assessment

Constraints:

- `n == tickets.length`
- `1 <= n <= 100`
- `1 <= tickets[i] <= 100`
- `0 <= k < n`