Linked lists

Each node of the list is a separate object:

```
class Node:
  def __init__(self, el, next=None):
    self.el = el
    self.next = next

>>> a = Node(13)
>>> b = Node(27, a)
>>> c = Node(99, b)
>>> c.el
99
>>> c.next.el
27
>>> c.next.next.el
13
```


Linked List

Let's make a class for a linked list. It contains a reference to the front of the list:

```
class LinkedList:
  def __init__(self):
    self._front = None

  def first(self):
    if self._front is None:
      raise EmptyListError
    return self._front

  def is_empty(self):
    return self._front is None
```


Basic list methods

Add an element at the front of the linked list:

```
def prepend(self, el)
```

Remove the first element:

```
def remove_first(self)
```

Insert an element after node:

```
def insert_after(self, node, el)
```

Remove element after node:

```
def remove_after(self, node)
```

Find element before node:

```
def before(self, node)
```

Find last node:

```
def last(self)
```


Linked list traversal

To compute the length of the linked list, or to display the list, we need to traverse the entire list:

```
  def __len__(self):
    if self.is_empty():
      return 0
    p = self._front
    count = 0
    while p is not None:
      count += 1
      p = p.next
    return count
```

Linked list with fast append

Appending to the list takes time linear in the length of the list.

To speed this up, the list needs to store a reference to both the first and last node of the list:

```
class LinkedList:
  def __init__(self):
    self._front = None
    self._rear = None
```

Now `append` is fast and easy:
`def append(self, el)`

But we have to be careful with all our other methods...
The `rear` field must be updated by every method of the `LinkedList` class.

Linked Queues

Remember the `Queue` ADT?

- `enqueue`
- `dequeue`
- `front`
- `is_empty`

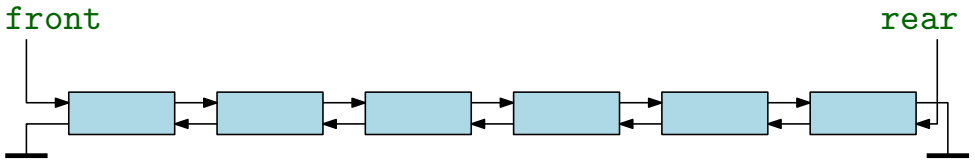
We can implement this as a linked list with fast append:

- `enqueue` appends at the rear of the list,
- `dequeue` removes from the front of the list.

Now you know why the two ends of a queue are called front and rear...

Doubly-linked lists

If we want to be able to quickly search a list both forward and backward, we need a doubly-linked list.

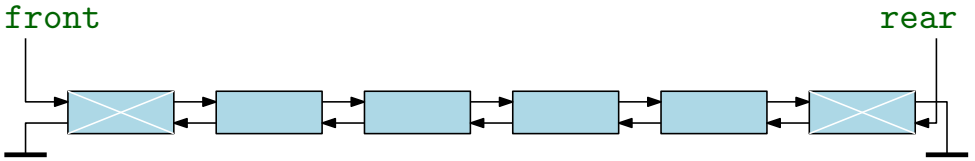



```
class Node:
  def __init__(self, el, next=None, prev=None):
    self.el = el
    self.next = next
    self.prev = prev
```


Sentinels

In doubly-linked lists, the code for inserting and removing elements needs to handle the case where the node is the first node and/or the last node separately.

We can simplify the code by using sentinel nodes. Sentinel nodes are "guarding" the two ends of the list, so that no special handling is necessary. Sentinel nodes do not contain elements. When we create an empty list, we automatically create the two sentinel nodes, which cannot be deleted.

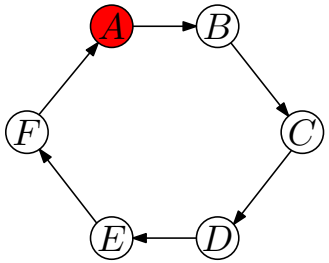


The Josephus Game

Given n player sitting in a circle, and a number m.

A hot potato starts at player 1, and is passed around m times. The player holding the potato then is eliminated, the next player gets the potato, and the game continues until only one player is left.

$n = 6,\ m = 2$



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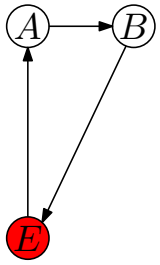

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What data structure to use?

We need a data structure to store the circle of people.

Required methods:

- Pass the potato to the next person.
- Delete the person holding the potato.

A doubly linked list does it all. A circular linked list would be even better, but we can simulate that easily.