LINKED LISTS

RECALL: ARRAYS

- Single chunk of memory underneath
- Access with `arrname[i]`
- Good for:
  - direct access/modification of elements at certain index $O(1)$
- Bad at:
  - inserting/deleting: need to shift and potentially get new array $O(n)$

ARRAYLIST

- A higher level list implementation - underneath uses arrays
- Convenient
- Efficient for:
  - accessing / setting value at index - O(1)
  - adding elements to the end - typically O(1), sometimes O(n)
- Not efficient for:
  - adding in middle - O(n)
  - removing - O(n)

LINKED LIST

- Data structure
- A list
  - Supports things like get, add, insert, remove, etc.
- Different underlying implementation
  - collection of nodes that are "linked" together
  - forms a sequence of elements

LINKED LIST - NODE

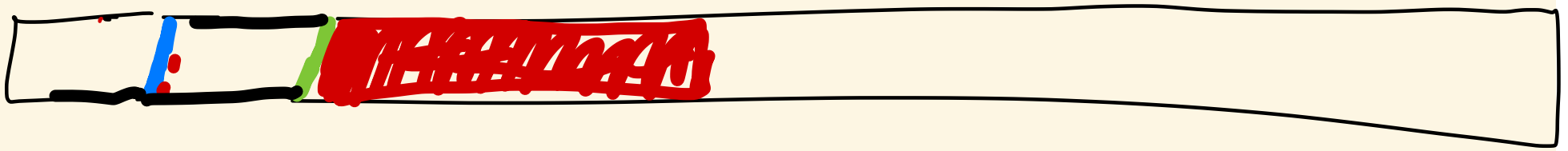
- Object
- Single value in list
- Stores
  - element
  - reference to next node (self-referential)

LINKED LIST

- Sometimes a separate class from node
- `head` - reference to first `Node` in list
  - adding to start is O(1)
- `tail` (optional) - reference to last node in list
  - makes adding to / removing from end O(1)

LINKED LIST (CONT.)

- downside:
  - access is inefficient (must traverse)
  - extra memory (store pointer to next for each node)



DOUBLY LINKED LIST

- Modification
  - `Node` has additional reference to previous
- Advantages
  - `remove(Node n1)` - more efficient (no need to traverse)
  - fast removal from end

Linked List

remove from end $O(n)$

accessing end $O(n)$

Linked List w/tail

removing from end: $O(n)$

accessing end: $O(1)$

Doubly linked list w/tail

removing from end: $O(1)$

accessing end: $O(1)$

```
public class Node {
    String val;
    Node next;
    //getters/setters
}

public class LL {
    Node head
}
```

```
public Node get(int index) {
    Node cur = head;
    try {
        for (int i = 0; i < index; i++)
            cur = cur.getNext()
    }
    catch (Exception e) {
        //do something with out of bounds
        throw new IllegalArgumentException();
    }
    return cur
```