Arrays, Linked Lists, and Graphs: Why Connecting your Data Makes Sense

Clair J. Sullivan, PhD
Data Science Advocate
Neo4j

@CJLovesData1

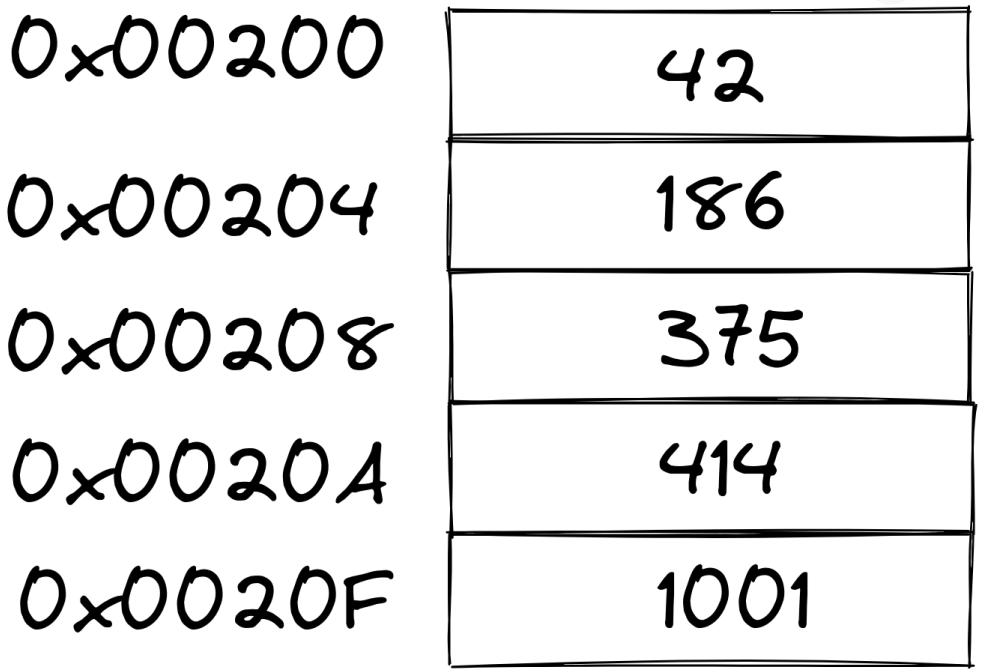
https://github.com/cj2001/data_umbrella_linked_lists

Where are we going?

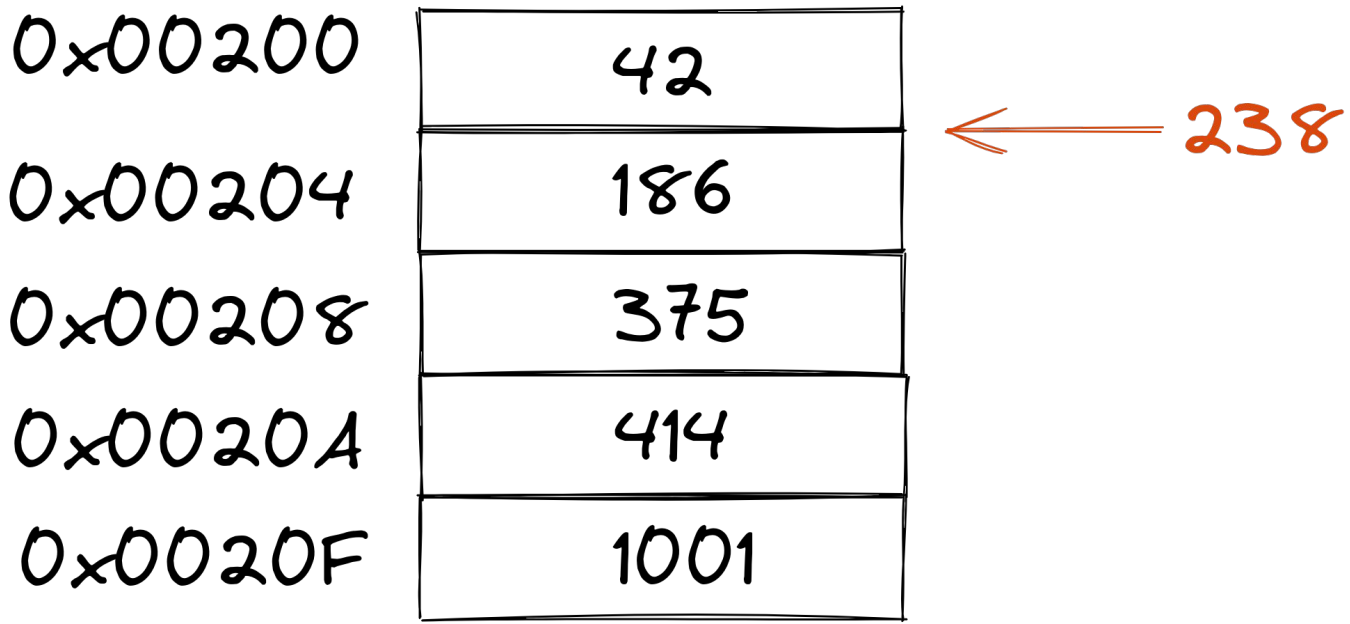
- Arrays
- Lists, a special array
- Linked lists
  - Singly-linked
  - Doubly-linked
- What to do when all of the above fails?

Arrays

```
my_data = [42, 186,
365, 414, 1001]
```

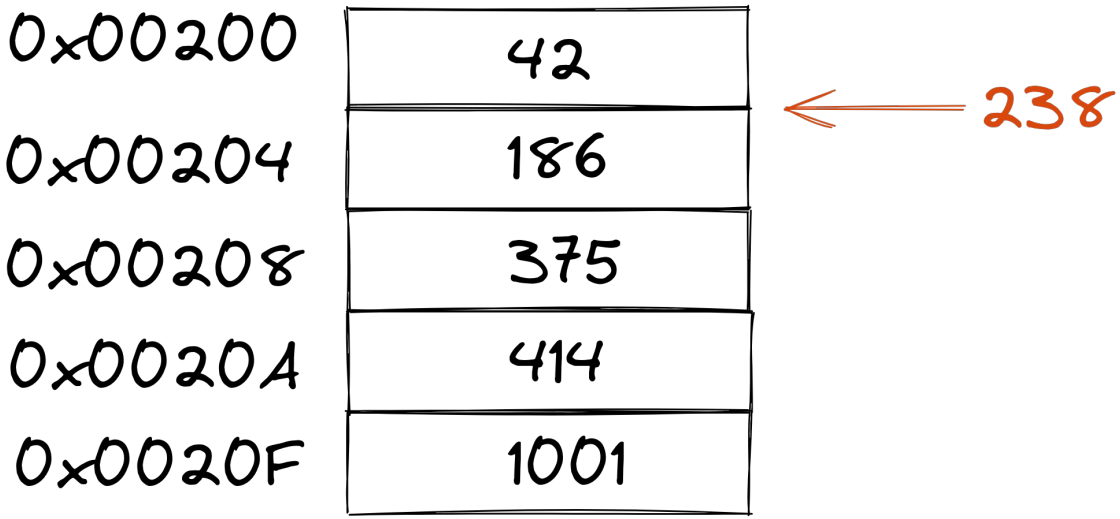


```
my_data.insert(1, 238)
my_data = [42, 238, 186, 365, 414, 1001]
```



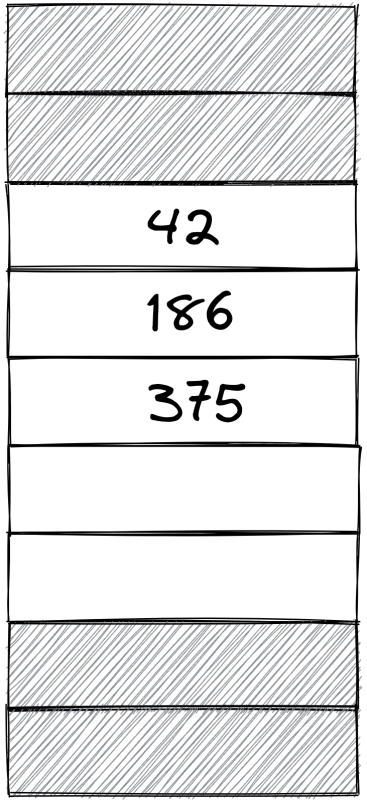
- Copy element 2 to element 3
- Copy element 3 to element 4
- …

O(n)

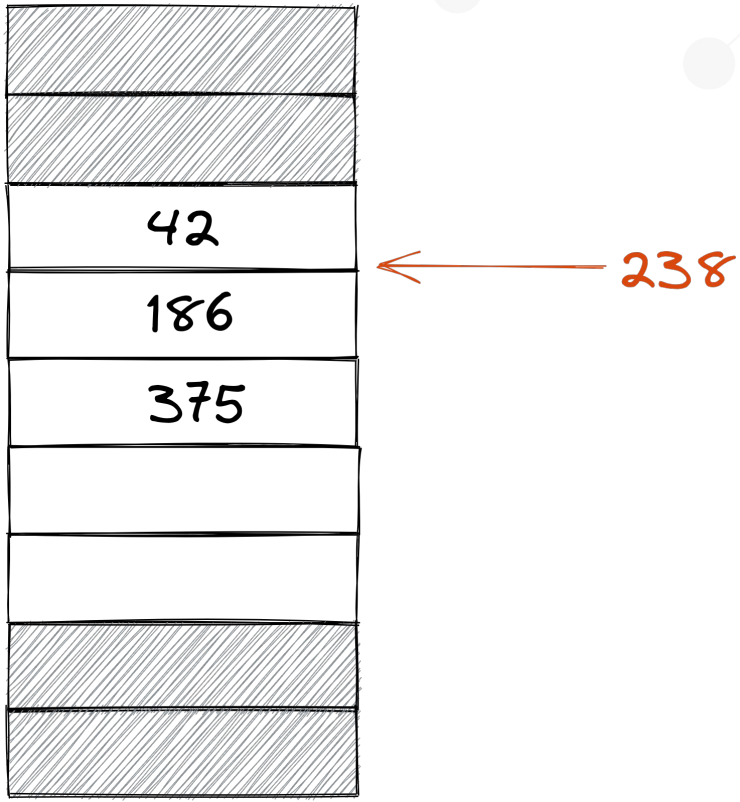


Lists: Dynamic Arrays

```
my_data = []
my_data.append(42)
my_data.append(186)
my_data.append(375)
```

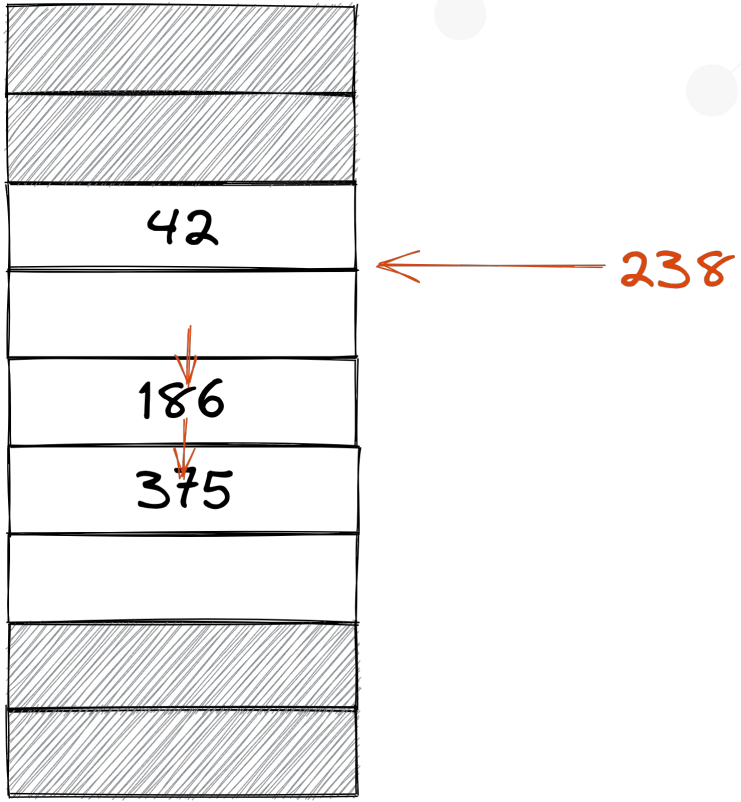


```
my_data.insert(1, 238)
```



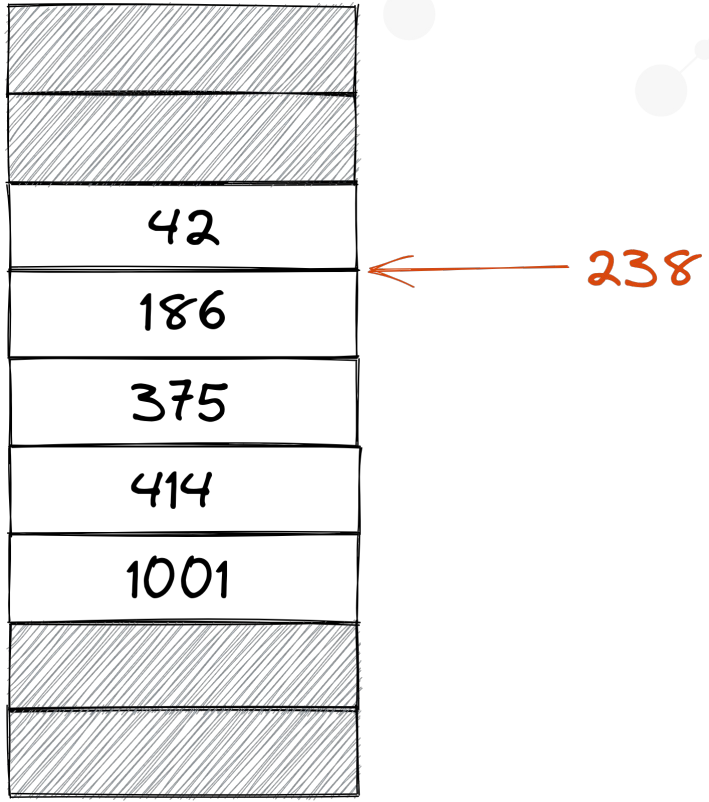
```
my_data.insert(1, 238)
```

O(n)



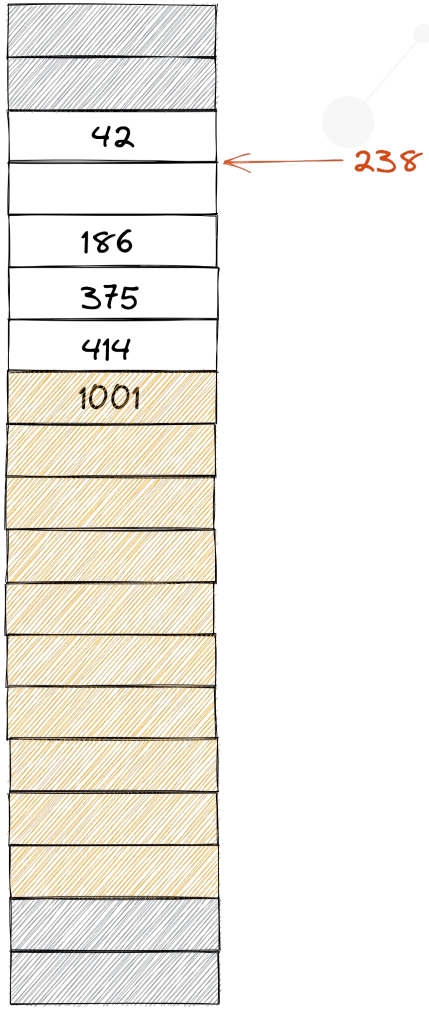
```
my_data = []
my_data.append(42)
my_data.append(186)
my_data.append(375)
my_data.append(414)
my_data.append(1001)

my_data.insert(1, 238)
```



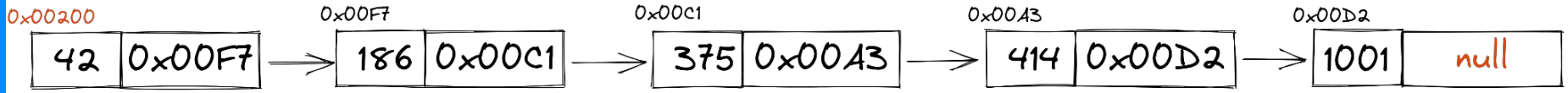
Inefficient because:

1. Swap elements
2. Allocate new memory
3. Copy elements from old memory into new memory



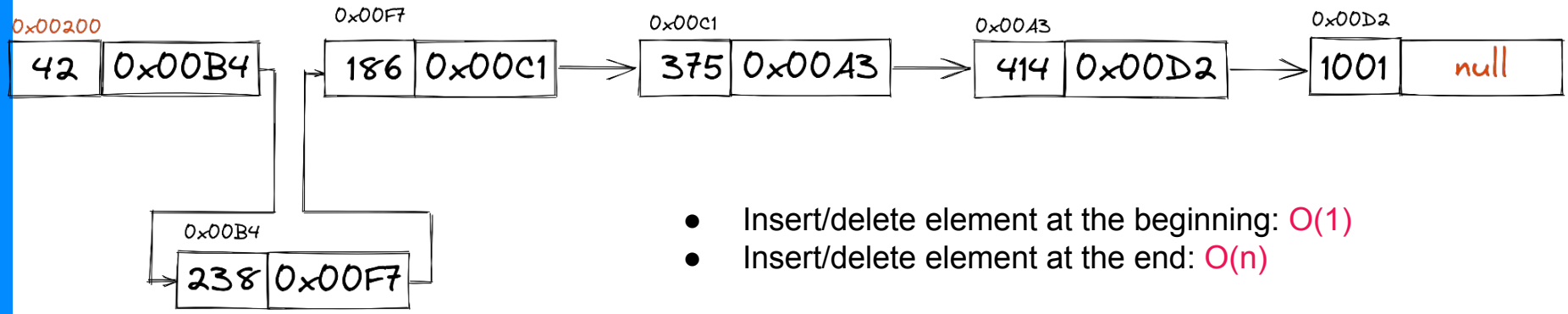
There must be a better way!!!

(Singly) Linked List



- Linked list traversal: O(n)
- Accessing elements by value: O(n)

List Insertion

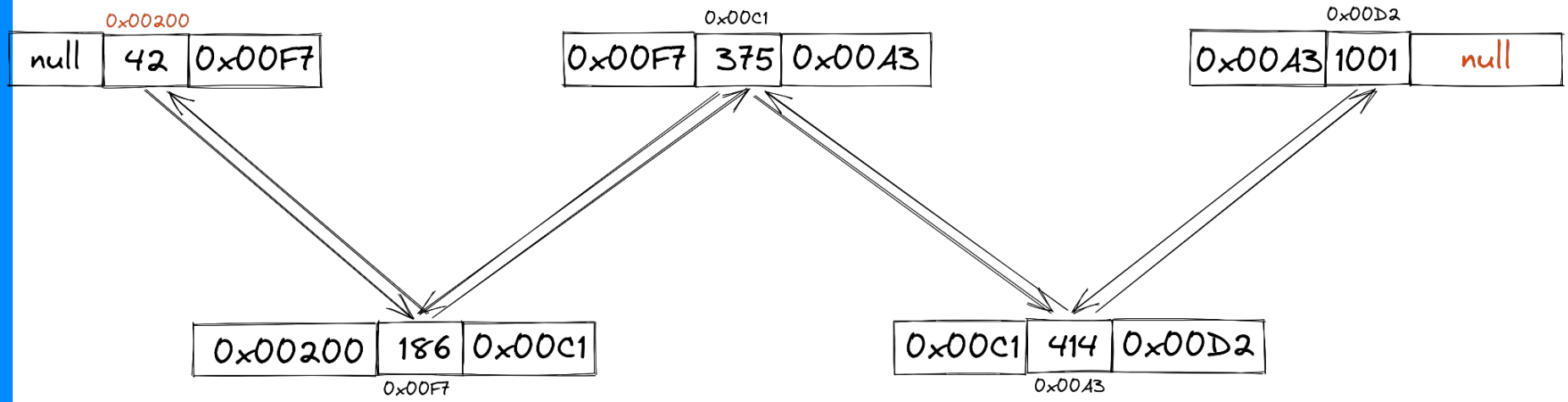


- Insert/delete element at the beginning: O(1)
- Insert/delete element at the end: O(n)

basic_linked_list.ipynb

Repository: https://github.com/cj2001/data_umbrella_linked_lists

(Doubly) Linked List



Benefits of Linked Lists vs. Arrays

Arrays win when:

- You are able to identify the index of the element you need: O(1)
- You expect to insert or delete elements at the end (assuming you are not expecting to go beyond allocated memory): O(1)

Linked lists win when:

- You need fast, easy insertion of new data: O(1)
- You don't want the burden of pre-allocating memory for the data structure

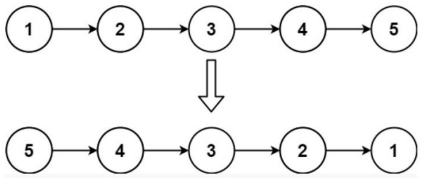
What You Need to Implement a Linked List

- A node class
  - Holds the data itself
    - Integers, numbers, complex objects
  - Requires:
    - Data
    - Next
    - Previous (only for doubly linked lists)
- A linked list class
  - Holds the pointers to the next element
  - Requires:
    - Head variable (pointer to first node)

LeetCode #206: Reverse Linked List (Iterative Solution)

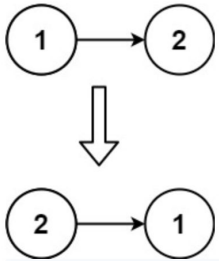
Given the head of a singly linked list, reverse the list, and return the reversed list.

Example 1:




```
Input: head = [1,2,3,4,5]
Output: [5,4,3,2,1]
```

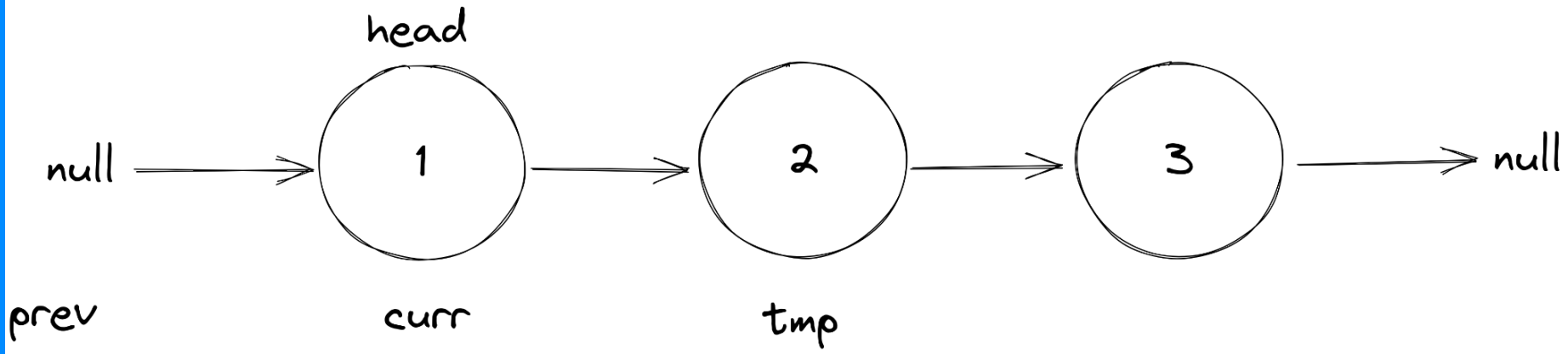
Example 2:

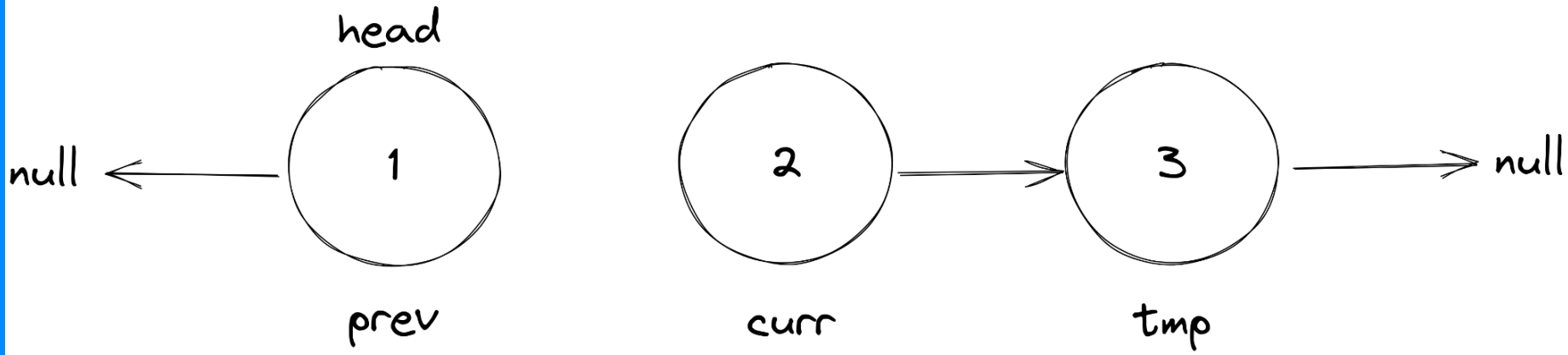


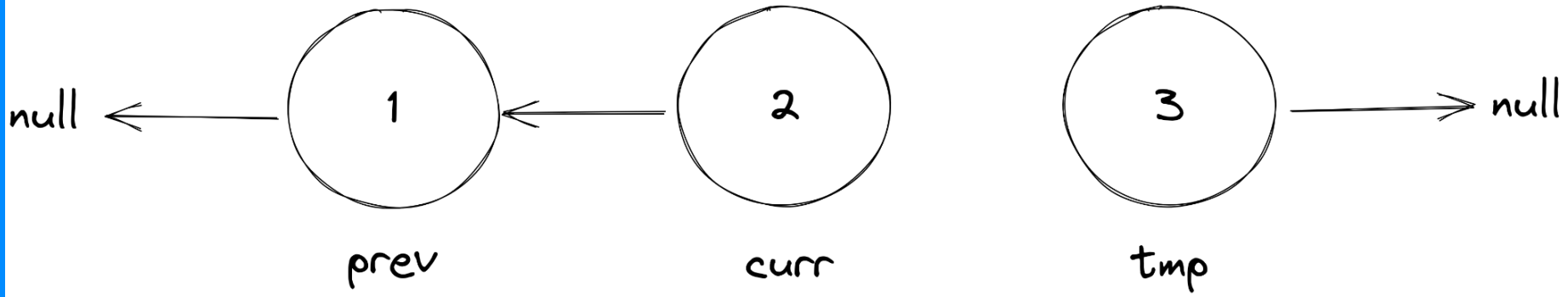

```
Input: head = [1,2]
Output: [2,1]
```

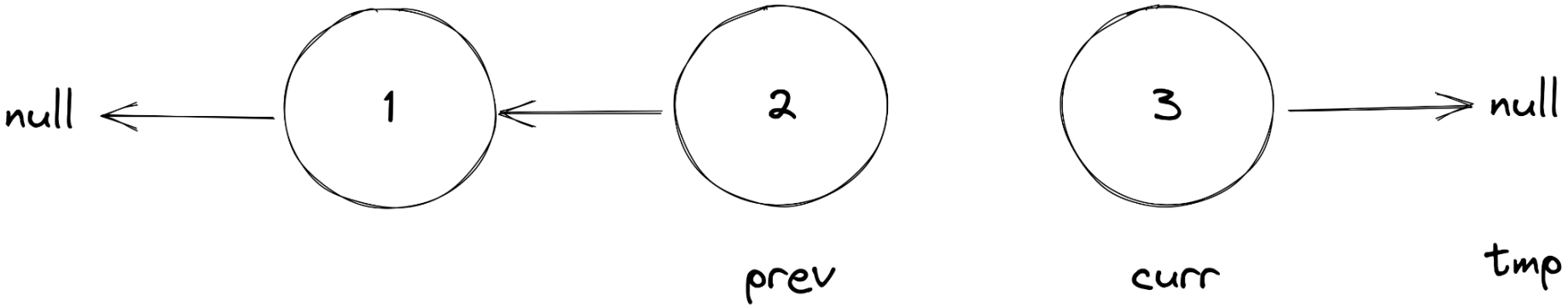
Example 3:

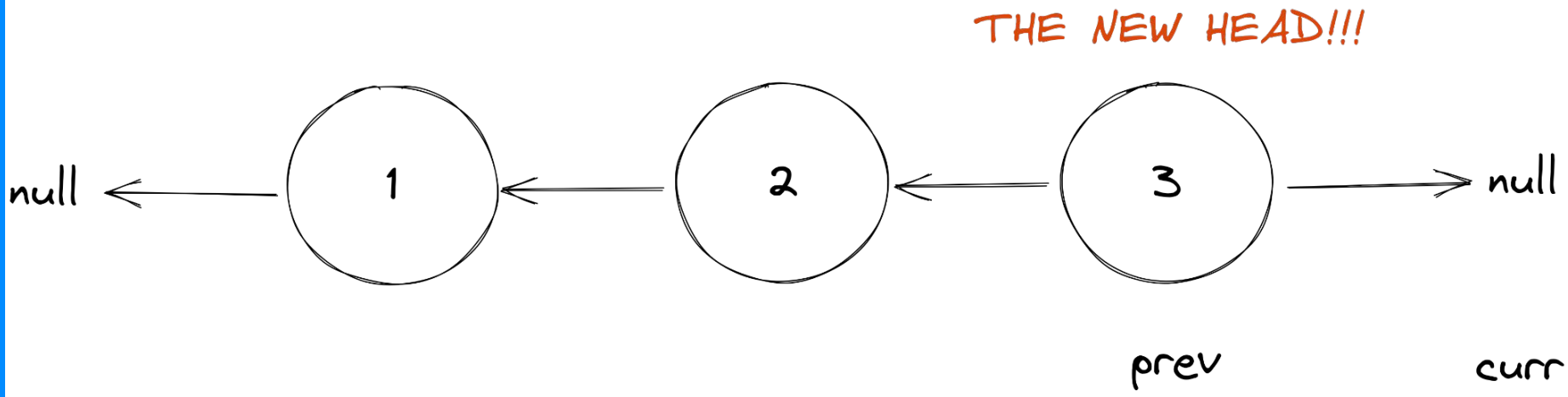
```
Input: head = []
Output: []
```











leetcode206.ipynb

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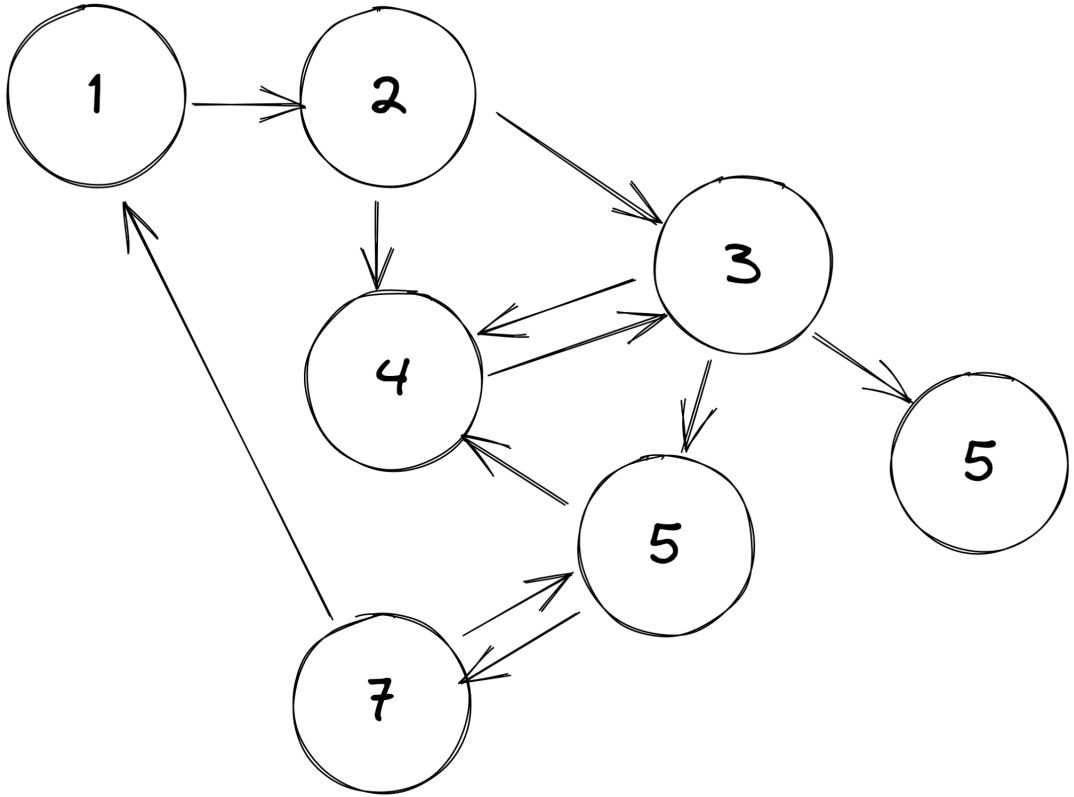
(This problem would have been a lot easier if we could have used a doubly-linked list!!!)

But what if…



Graphs to the rescue!

- A collection of nodes and relationships (AKA edges)
- Nodes can have:
  - Labels (multiple?)
  - Properties (multiple?)
- Relationships can have:
  - Labels
  - Properties (multiple?)
- Graphs can have multiple node and relationship types

How to Get into Graphs with Python

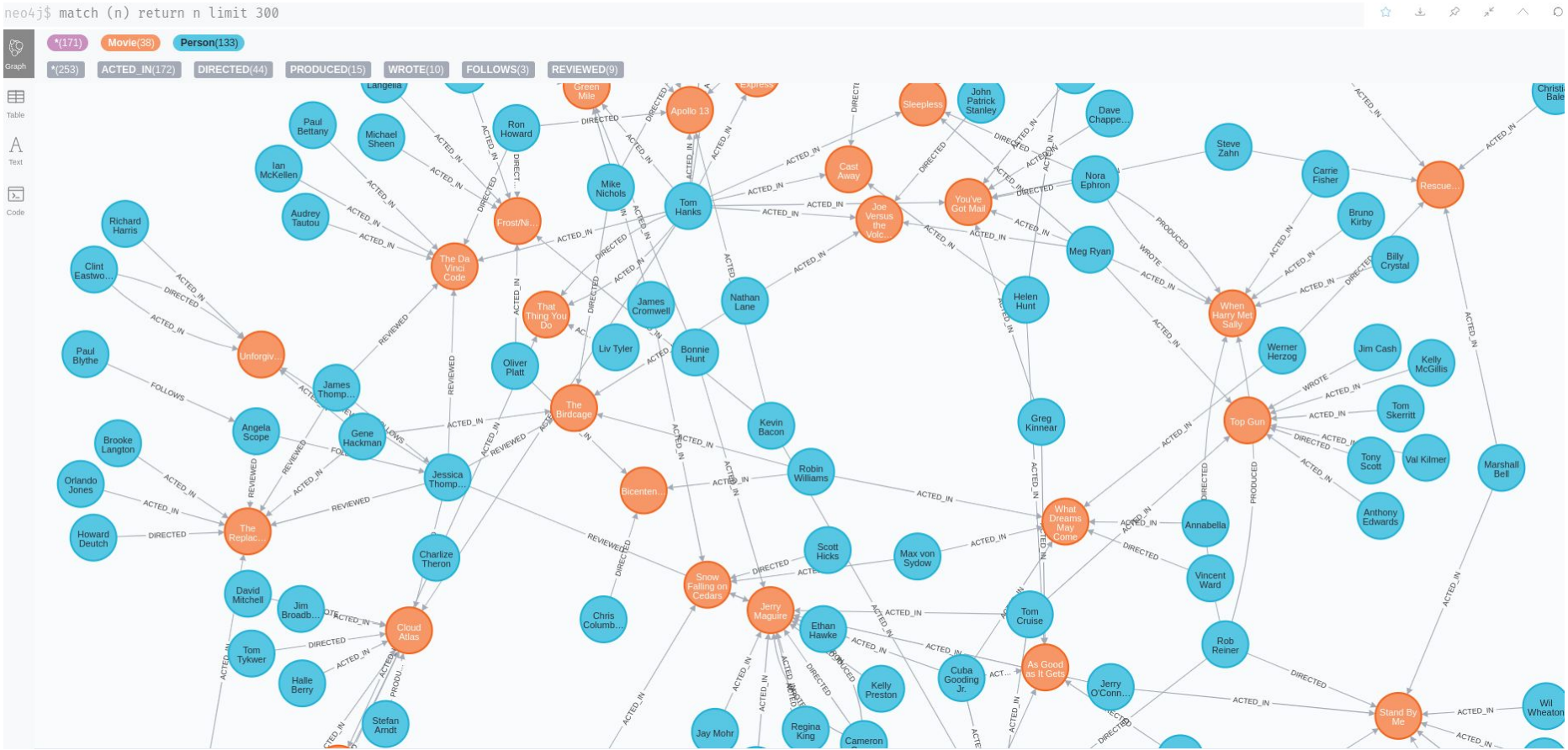
In-memory via Python packages

- Simple
- Minimal overhead in terms of database management
- Easy to query directly from Python

Graph databases

- Can involve infrastructure complexity
- Like SQL, typically uses its own query language
- Scalable
- Suited for heavy compute, complicated queries, data science, machine learning tasks

sandbox.neo4j.com



basic_graph.cql

Repository: https://github.com/cj2001/data_umbrella_linked_lists

got_queries.cql

Repository: https://github.com/cj2001/data_umbrella_linked_lists

graph_data_science.ipynb

Repository: https://github.com/cj2001/data_umbrella_linked_lists

Recap

- Arrays and lists are limited by insertion problems (O(n))
- Linked lists are beneficial because:
  - Insertion is O(1)
  - You don’t need to pre-allocate memory
- As network of nodes becomes more complicated, it is best to move to a graph representation because:
  - Easy query of complicated networks
  - Can take advantage of a variety of Python packages
  - Can scale when implemented in a graph database

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Thank you!

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