

빅 데이터 혁신 공유 대학

# 파이썬으로 배우는 데이터 구조

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한동대학교 전산전자공학부

김영섭 교수



교육부



한국연구재단



# Data Structures in Python

## Chapter 3 - 3

- Linked List
- OOP Inheritance
- ListUnsorted Class
- ListSorted Class & Iterator

# Agenda

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- Linked List
  - Introduction
  - The Node class
  - The Linked List ADT
  - Comparing Implementations

# Review

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- The `list` in Python is a powerful, yet simple, collection mechanism that provides the programmer with a wide variety of operations.
  - We may use Python `list` to implement both Stack and Queue.
- A Python `list` stores each element in **contiguous memory** if possible.
  - It is an array-based sequence.
  - This makes it possible to access any element in  $O(1)$  time.
  - However, insertion or deletion elements at the beginning of the list takes  $O(n)$ .

# Linked List

- An **array** provides the more **centralized** representation, with one large chunk of memory capable of accommodating references to many elements.

start	54
	26
	93
	17
	77
end	31

An array-based collection

A Linked List

# Linked List

- An **array** provides the more **centralized** representation, with one large chunk of memory capable of accommodating references to many elements.
- A **linked list** relies on a more **distributed** representation in which a lightweight object, known as a **node**, is allocated for each element.
  - Each node maintains a **reference** to its element and one or more references to neighboring nodes in order to collectively represent the linear order of the sequence.

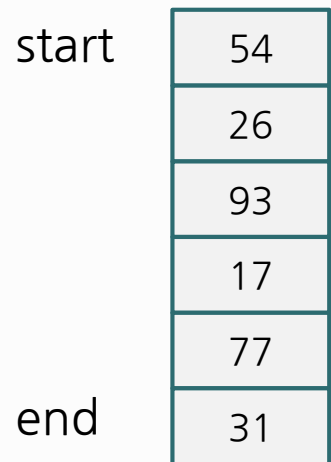
start	54
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An array-based collection

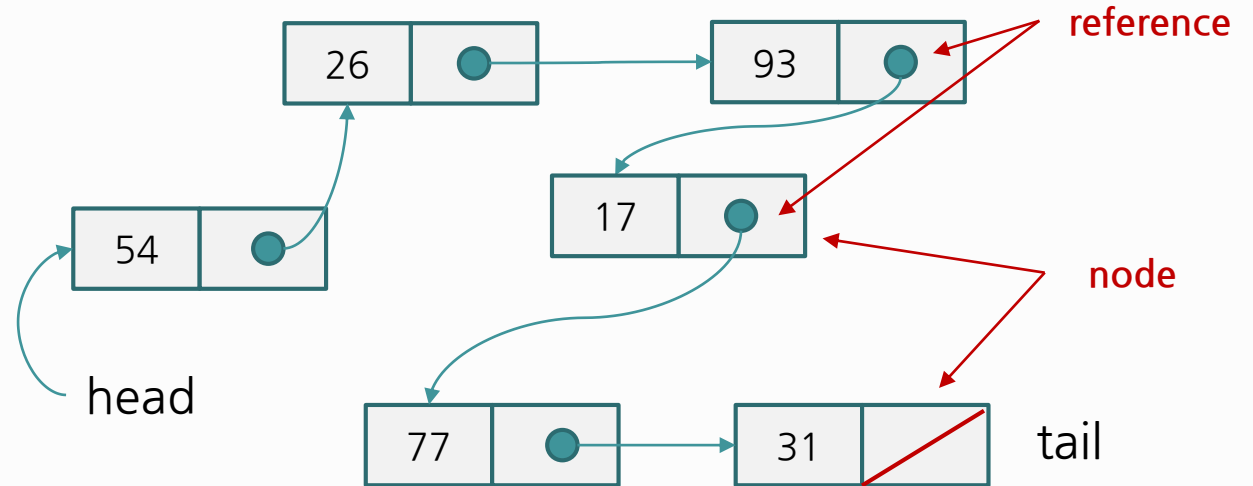
A Linked List

# Linked List

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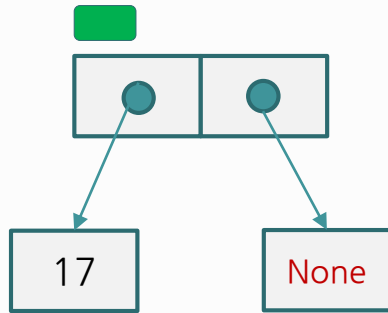
An array-based collection



A Linked List

# A Node

- A **node** is the basic building block of a linked list.
- It contains the **data** as well as a **link** to the **next node** in the list.
- The node's element references an arbitrary object that is an element of the sequence (17 in this example), which the next references the subsequent node the linked list or **None**.



a node in memory



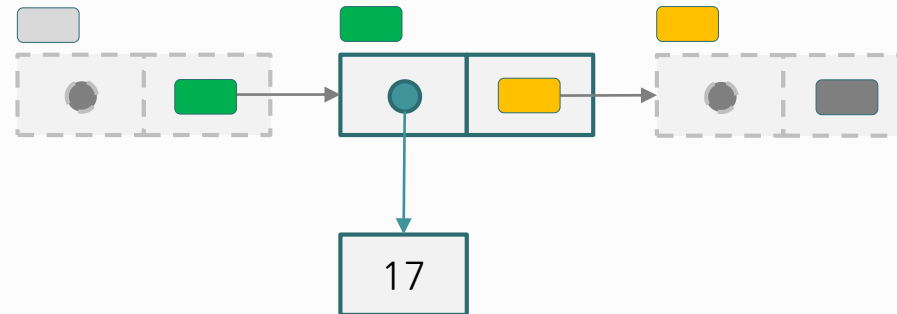
a compact representation  
of a node



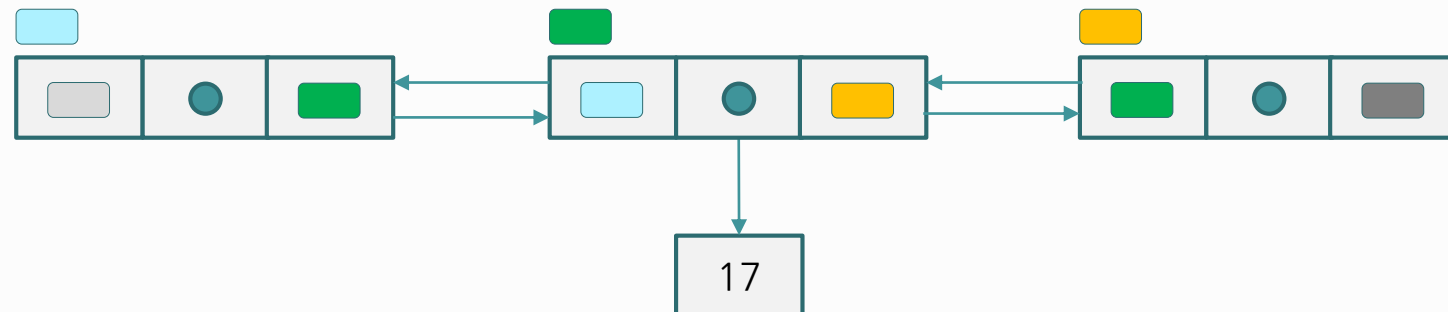
# Singly Linked Lists vs Doubly Linked List

- An example of a **node** instance that forms part of a linked list.
- Each node maintains a reference to its element and **one or more references** to neighboring nodes in order to collectively represent the linear order of the sequence.

A Singly Linked List



A Doubly Linked List



# Terminology

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- **head and tail:**

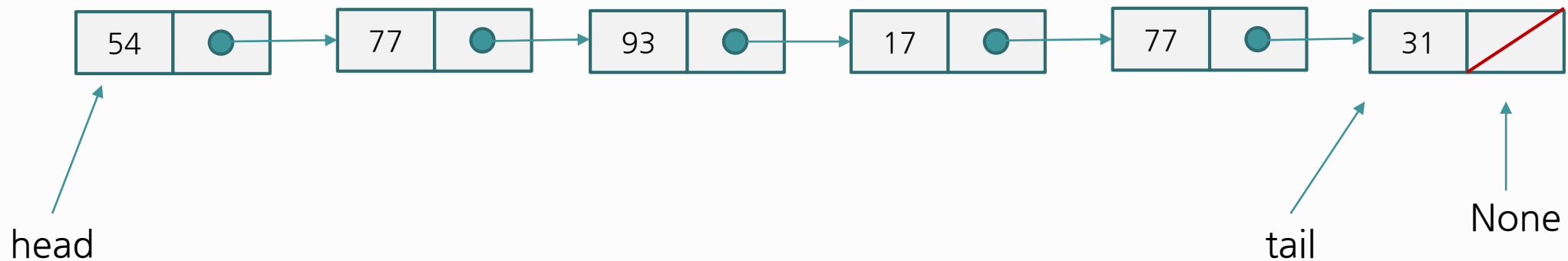
- The first and last node of a linked list are known as the **head** and **tail** of the list, respectively.

- **traverse**

- By starting at the head and moving from one node to another by following each node's next reference, we can reach the tail of the list.
- We can identify the tail as the node having None as its next reference. This process is commonly known as **traversing** the linked list.

# Terminology

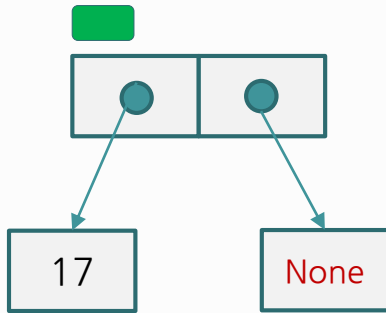
- An example of a singly linked list whose elements are number.
  - The list instance maintains a member named **head** that identifies the first node of the list, and another member named **tail** that identifies the last node of the list.
  - The **None** object is denoted as a slash.



For a compact illustration of a singly linked list, with elements embedded in the nodes.

# The Node class

- A **node** is the basic building block of a linked list.
- It contains the **data** as well as a **link** to the **next node** in the list.
- The node's element references an arbitrary object that is an element of the sequence (17 in this example), which the next references the subsequent node the linked list or **None**.



a node in memory



a compact representation  
of a node

# The Node class

- A **node** may be defined as shown below:

```
class Node:
    def __init__(self, data):
        self._data = data
        self._next = None

node = Node(17)
```



an implementation of a node

# The Node class

- A **Node** class may be defined as shown below:

```
class Node:
    def __init__(self, data):
        self._data = data
        self._next = None

    def get_data(self):
        return self._data

    def get_next(self):
        return self._next

    def set_data(self, data):
        self._data = data

    def set_next(self, next):
        self._next = next

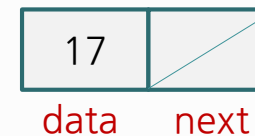
if __name__ == "__main__":
    node = Node(17)
```

getting the next node linked; it may be None.

setting the data of the current node

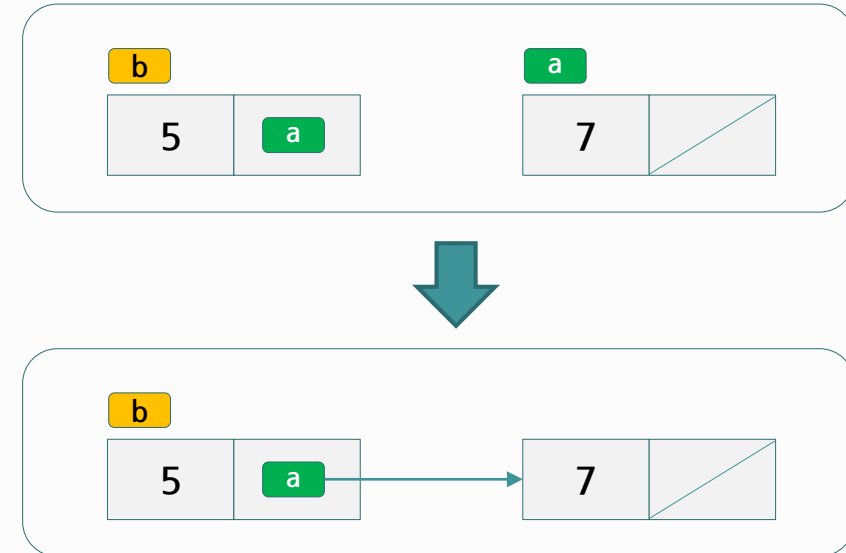
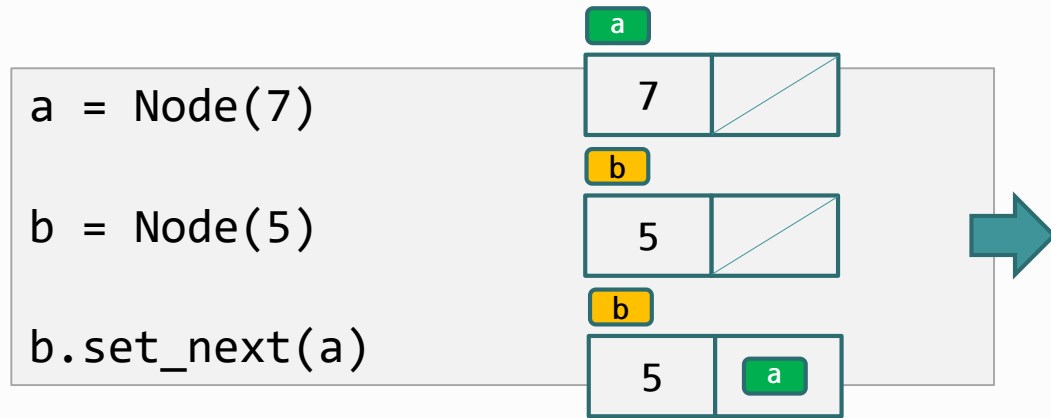
setting the next of the current node  
namely, linking the next node

node



# The Node class - Chain of nodes

- Chain of nodes:



The node reference **'a'** is stored in **b.next**;  
Now, we just keep the node reference of **'b'**  
which is called the head of the linked list.

# The Node class - Chain of nodes

- Change the data of two nodes to 55 and 77 in the linked list, respectively. The head of the list, b is given.



- Step 1:

```
b.set_data(55)
```



- Step 2:

```
x = b.get_next()      using a temporary name, x  
x.set_data(77)
```

```
b.get_next().set_data(77)
```

without using a temporary name





# Exercise 1

- Step 1: Draw a linked list diagram. Which one is the first node of the list?

```
def print_chain(node):  
    while not node == None:  
        print(node.get_data(), end = " ")  
        node = node.get_next()
```

```
a = Node(15)  
b = Node(26)  
c = Node(37)  
d = Node(48)
```

(1) Create nodes.

```
b.set_next(a)  
c.set_next(d)  
d.set_next(b)
```

(2) Link nodes.

(1) Create nodes.

(2) Link nodes.

(3) Linked list

# Exercise 1

- Step 1: Draw a linked list diagram. Which one is the first node of the list?

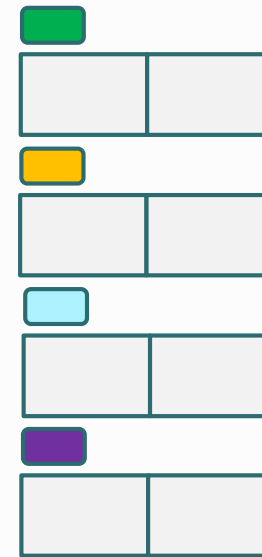
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    while not node == None:  
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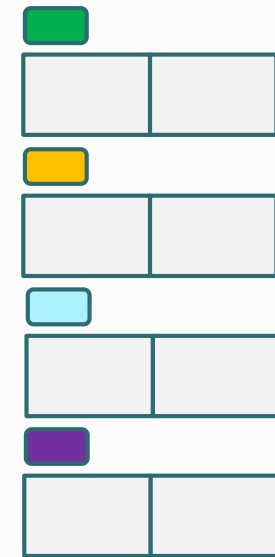
(1) Create nodes.

```
b.set_next(a)  
c.set_next(d)  
d.set_next(b)
```

(2) Link nodes.



(1) Create nodes.



(2) Link nodes.

(3) Linked list



# Exercise 1

- Step 2: What is the output of the following program?

```
def print_chain(node):  
    while not node == None:  
        print(node.get_data(), end = " ")  
        node = node.get_next()
```

```
a = Node(15)  
b = Node(26)  
c = Node(37)  
d = Node(48)
```

```
b.set_next(a)  
c.set_next(d)  
d.set_next(b)
```

```
print_chain(a)  
print()  
print_chain(b)  
print()  
print_chain(c)
```

(3) Linked list



## Exercise 1 Observation

- Step 2: What is the output of the following program?

```
def print_chain(node):  
    while not node == None:  
        print(node.get_data(), end = " ")  
        node = node.get_next()
```

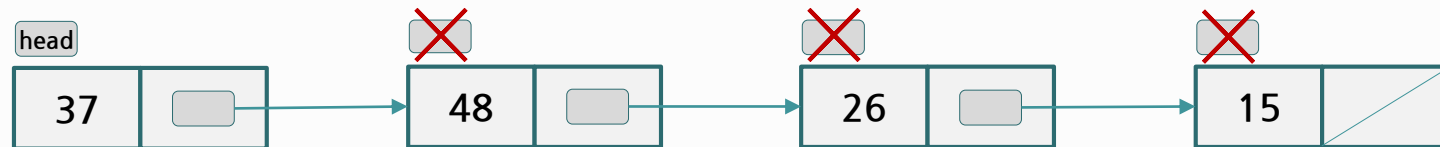
```
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c = Node(37)  
d = Node(48)
```

```
b.set_next(a)  
c.set_next(d)  
d.set_next(b)
```

```
print_chain(a)  
print()  
print_chain(b)  
print()  
print_chain(c)
```

- Notice that only one reference is passed to the function, and others are unknown in the function.
- You may **traverse the whole list** if the first node reference or the **head** is known.

(3) Linked list



# Linked List ADT

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- `LinkedList()`
  - Creates a new list that is empty and returns an empty list.
- `is_empty()`
  - Tests to see whether the list is empty and **returns** a Boolean value.
- `size()` and `__len__()`
  - Returns the number of nodes in the list.
- `__str__()`
  - Returns contents of the list in human readable format.
- `push(data)`, `push_back(data)`
  - Pushes a new node with data to the list.
- `pop_front()`, `pop(data)`
  - Removes the node with data from the list.
- `find(data)`
  - Finds for the data in the list and **returns** a Boolean value.

# Summary

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- Reference variables can be used to implement the data structure known as **a linked list**.
- Each reference, "next", in a linked list is a reference to the next node in the list.
- Any element in a list can be accessed, however, you must traverse a linked list to access a particular node using the **head** node available.

# Data Structures in Python

## Chapter 3 - 3

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