COMP108
Data Structures and Algorithms

Data structures - Linked Lists (Part I)

Professor Prudence Wong

pwong@liverpool.ac.uk

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Outline

Linked lists

- What are linked lists?
- Traversing a linked list
- Searching over a unsorted/sorted list
- Inserting a node to a linked list
- Deleting a node from a linked list

Learning outcome:

- Understand what **linked lists** are and their associated algorithms

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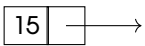
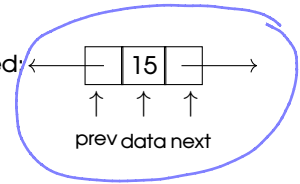
- each element (**node**) has a **data** field and one (or two) pointers linking to the **next** (or **previous**) element in the list

singly linked: 

doubly linked: 

node

node.data

node.next

node.prev

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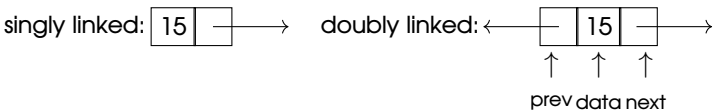

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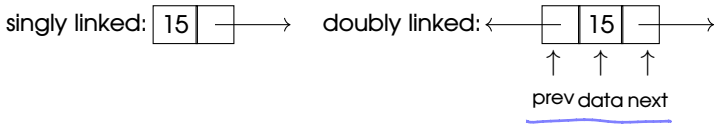

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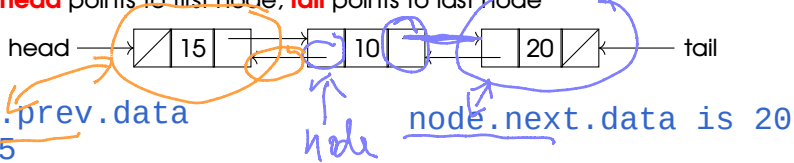

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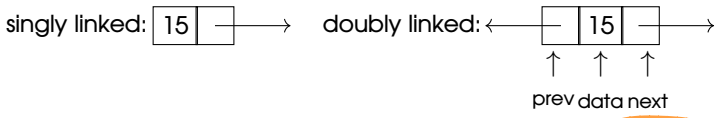

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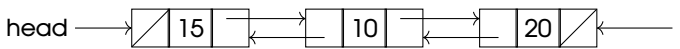


- E.g., head.data is 15; head.next.data is 10; tail.data is 20, tail.prev.prev.data is 15

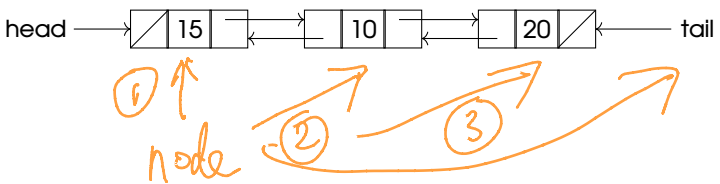
NIL .data

tail.next.data? error

head.next.prev.data is 15

Linked lists - Algorithm - traversing

Traversing and output each element of a linked list



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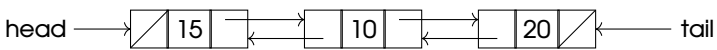
node ← head
while node ≠ NIL do
begin


end
```



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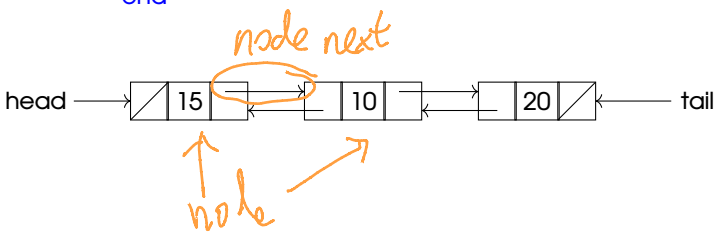

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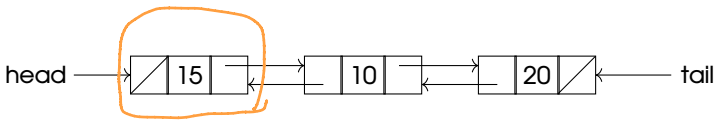
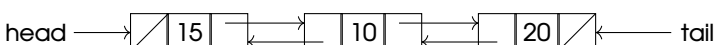


Linked lists - Algorithm - searching

Searching if a value **key** is in a linked list



Linked lists - Algorithm - searching

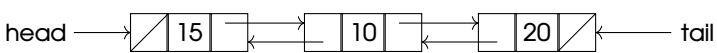
Searching if a value **key** is in a linked list

```
node ← head, found ← false        flag variable found
while node ≠ NIL AND found == false do
begin




end
if found == true then
      output ``FOUND!''
else output ``NOT FOUND!''
```

} expected output code



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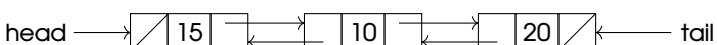

Linked lists - Algorithm - searching

Searching if a value **key** is in a linked list

```
node ← head, found ← false
while node ≠ NIL AND found == false do
begin
    if node.data == key then
        found ← true
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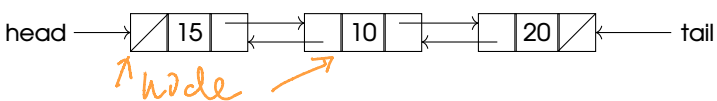
```



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Alternatively,

```
node ← head
while node ≠ NIL AND node.data ≠ key do
    node ← node.next
if node == NIL then
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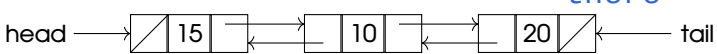
`if node.data == key??`
`ANSWER: no, because there may be error (nil pointer exception) when key is not there`



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n elenments
best case: O(1)
worst case: O(n)

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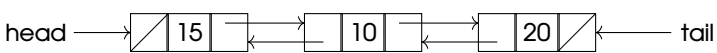
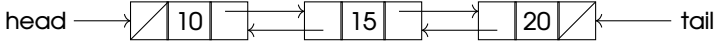
Time complexity?



Linked list - Searching over a sorted list

- Recall that if the values in an array are sorted, say ascending, we can use binary search to search efficiently.
- However, even if the values in a linked list are sorted, we still can't use binary search. Why?
- We can modify the sequential search algorithm and may terminate the loop earlier. How?



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- Under what conditions would the while loop stop?

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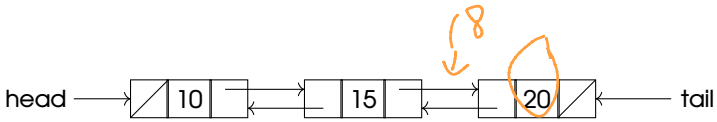

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node $\leftarrow$ head
while node $\neq$ NIL AND **node.data** $<$ **key** do
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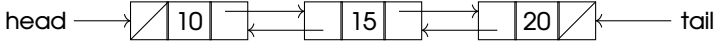
  1. **node is NIL:** whole list is smaller than key



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- Under what conditions would the while loop stop?
  1. **node is NIL:** whole list is smaller than key
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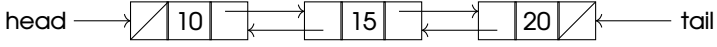

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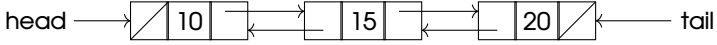

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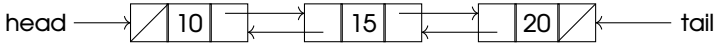

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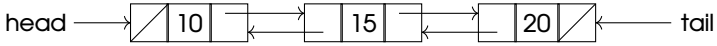
- Why need to check if node == NIL and not simply if node.data == key?



Time complexity

Are the following statements correct about an array / a linked list with n elements?

The time complexity of searching over an array is $O(n)$. ✓

The time complexity of searching over a sorted array is $O(\log n)$. ✓

The time complexity of searching over a linked list is $O(n)$. ✓

The time complexity of searching over a sorted linked list is $O(\log n)$. ✗

$O(n)$

Summary: Linked lists - Traversing & Searching

Next: Linked lists - Insertion & Deletion

For note taking