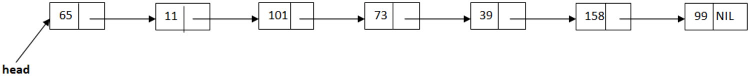
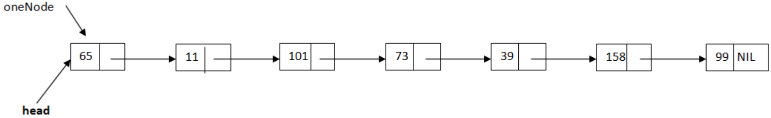
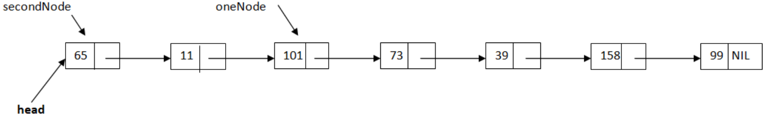
Algorithmic problems using Linked Lists

- Find the n^{th} node from the end of a SLL.
- Simple approach: go through all elements to count the length of the list. When we know the length, we know at which position the n^{th} node from the end is. Start again from the beginning and go to that position.
- Can we do it in one single pass over the list?
- We need to use two auxiliary variables, two nodes, both set to the first node of the list. At the beginning of the algorithm we will go forward $n - 1$ times with one of the nodes. Once the first node is at the n^{th} position, we move with both nodes in parallel. When the first node gets to the end of the list, the second one is at the n^{th} element from the end of the list.

- We want to find the 3^{rd} node from the end (the one with information 39)




oneNode
65
11
101
73
39
158
99
NIL
head


secondNode
oneNode
65
11
101
73
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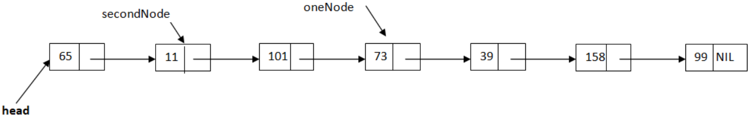
158
99
NIL
head


secondNode
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NIL
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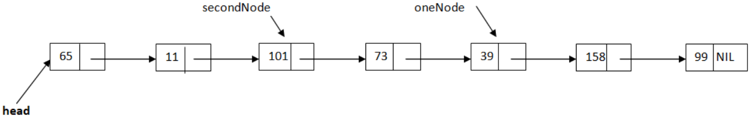
secondNode
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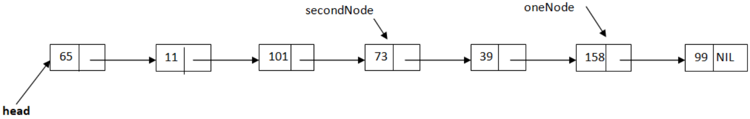
secondNode
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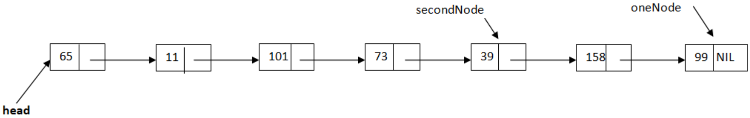
secondNode
oneNode
65
11
101
73
39
158
99
NIL
head

N-th node from the end of the list

```
function findNthFromEnd (sll, n) is:
//pre: sll is a SLL, n is an integer number
//post: the n-th node from the end of the list or NIL
    oneNode $\leftarrow$ sll.head
    secondNode $\leftarrow$ sll.head
    position $\leftarrow$ 1
    while position $<$ n and oneNode $\neq$ NIL execute
        oneNode $\leftarrow$ [oneNode].next
        position $\leftarrow$ position $+$ 1
    end-while
    if oneNode $=$ NIL then
        findNthFromEnd $\leftarrow$ NIL
    else
    //continued on the next slide...
```

N-th node from the end of the list

```
        while [oneNode].next $\neq$ NIL execute
            oneNode $\leftarrow$ [oneNode].next
            secondNode $\leftarrow$ [secondNode].next
        end-while
        findNthFromEnd $\leftarrow$ secondNode
    end-if
end-function
```

- Is this approach really better than the simple one (does it make fewer steps)?

- Write a subalgorithm which rotates a singly linked list (moves the first element to become the last one).
    - We have to do two things: remove the first node and then attach it after the last one.
    - Special cases:
        - an empty list
        - list with a single node

```
**subalgorithm** rotate(sll) **is:**
    **if NOT** (sll.head = NIL **OR** [sll.head].next = NIL) **then**
        first ← sll.head //*save the first node*
        sll.head ← [sll.head].next *remove the first node*
        current ← sll.head
        **while** [current].next ≠ NIL **execute**
            current ← [current].next
        **end-while**
        [current].next ← first
        [first].next ← NIL
        //*make sure it does not point back to the new head node*
    **end-if**
**end-subalgorithm**
```

- Complexity: $\Theta(n)$

Think about it

- Given the first node of a SLL, determine whether the list ends with a node that has NIL as *next* or whether it ends with a cycle (the *last* node contains the address of a previous node as *next*).
- If the list from the previous problems contains a cycle, find the length of the cycle.
- Find if a SLL has an even or an odd number of elements, without counting the number of nodes in any way.
- Reverse a SLL non-recursively in linear time using $\Theta(1)$ extra storage.