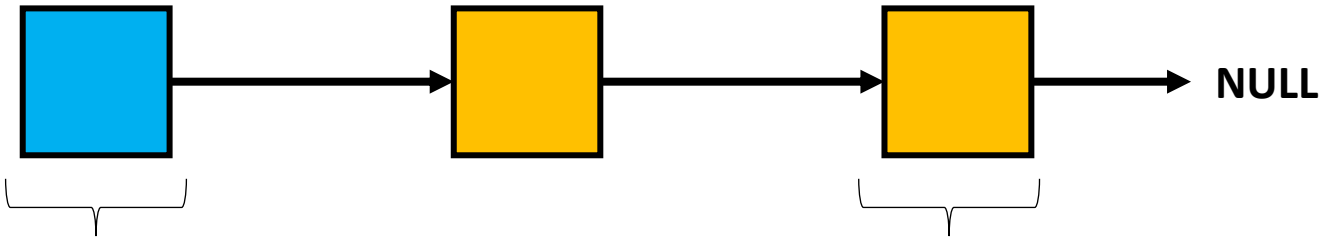
Linked List Data Structure
(Algorithms and Data Structures)

Linked Lists

- it is another **data structure** – so the aim is to be able to store items efficiently (*insertion* and *removal* operations)
- arrays have a huge disadvantage: there may be „holes” in the data structure and we have to shift a lot of items
- this problem can be eliminated by **linked lists**

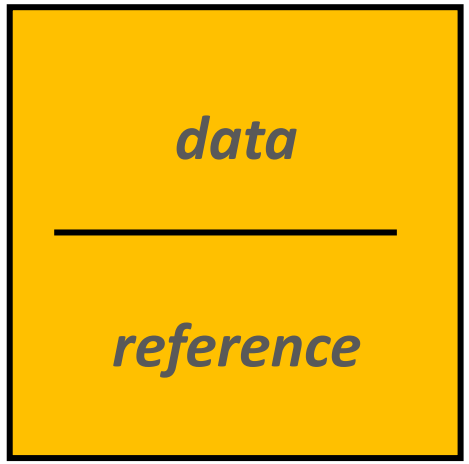


we have access to the first node of the linked list (head node)

- other items can be accessed starting with this node -

*last node of the linked list is pointing to a **NULL***

Linked Lists



- every node stores the **data** itself and a **reference** the next node in the linked list data structure
- this is why **linked lists** need more memory than arrays
- it has an advantage – there can not be „holes” in the data structure so **there is no need for shifting items**

Linked Lists

- easy data structures and easy to implement them
- the items are not stores next to each other in the memory – **so there is no random indexing**
- We can implement more complex data structures and abstract data types such as *stacks* and *queues*

FINDING ARBITRARY ITEM IN THE LINKED LIST STILL HAS O(N) LINEAR RUNNING TIME

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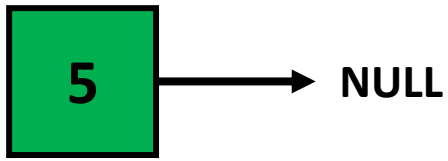

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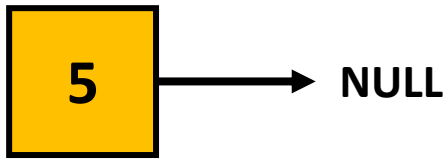

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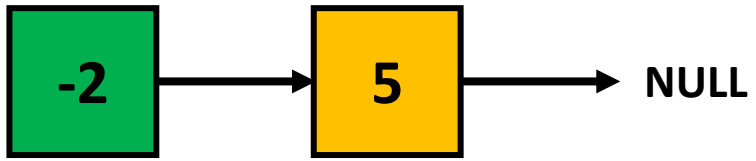

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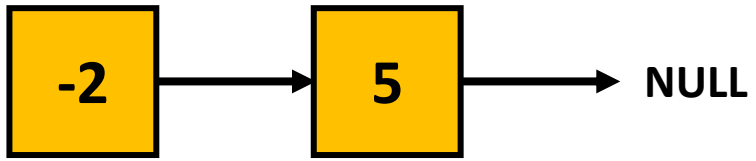

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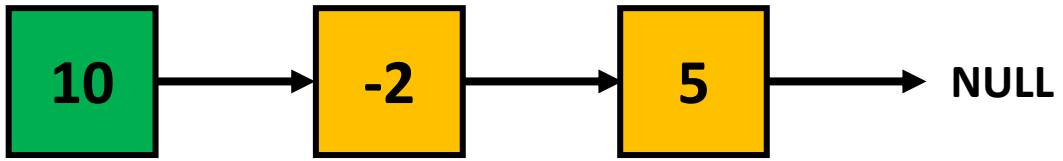

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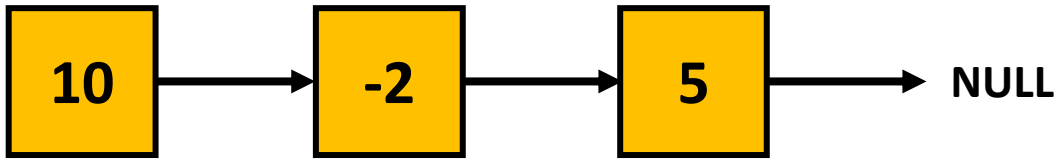

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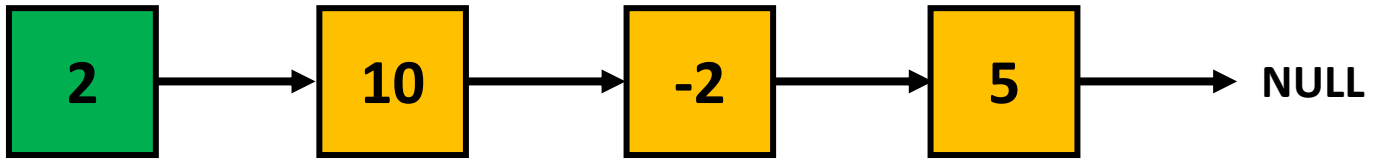

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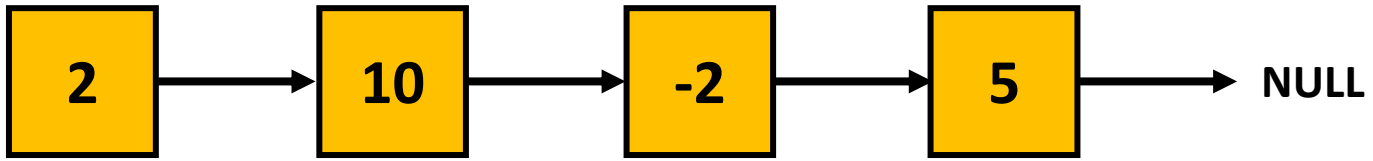

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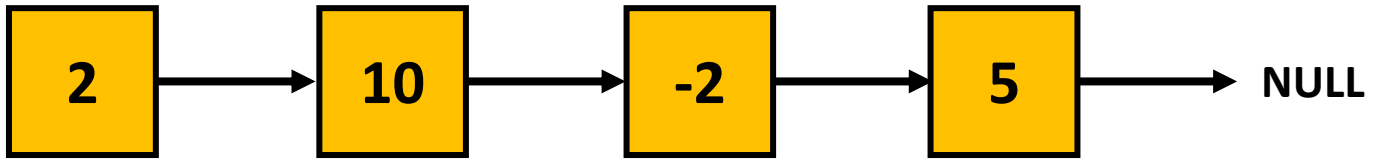

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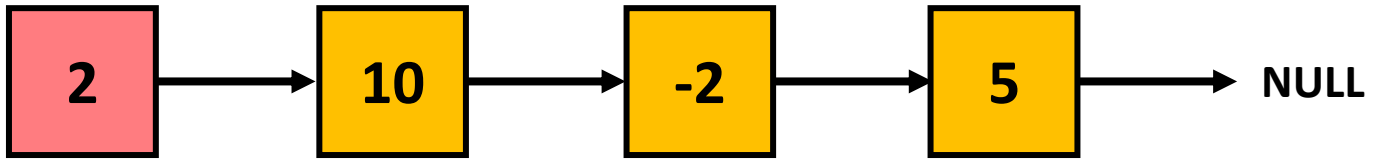

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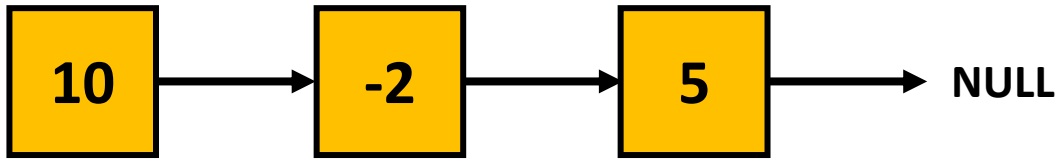

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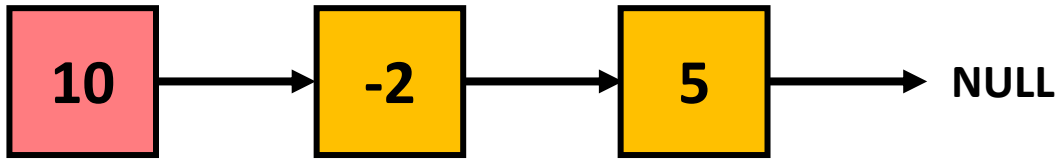

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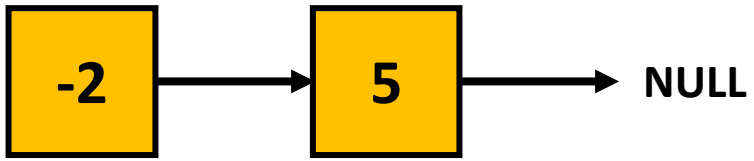

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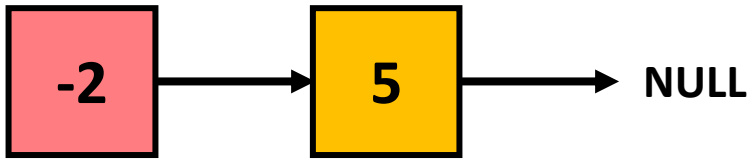

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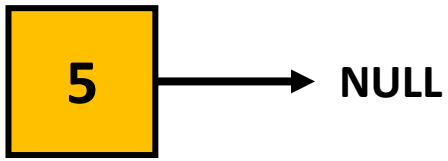

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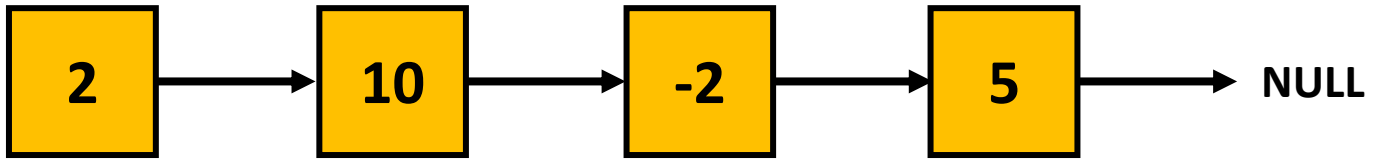

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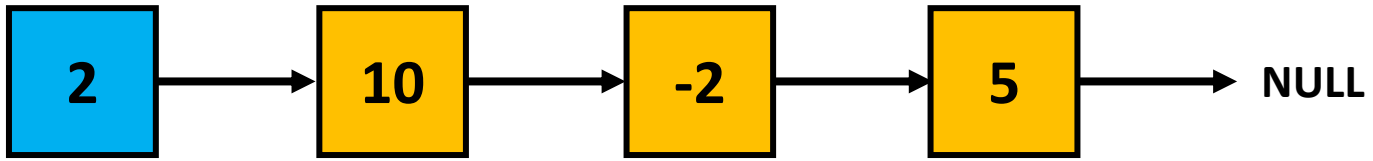

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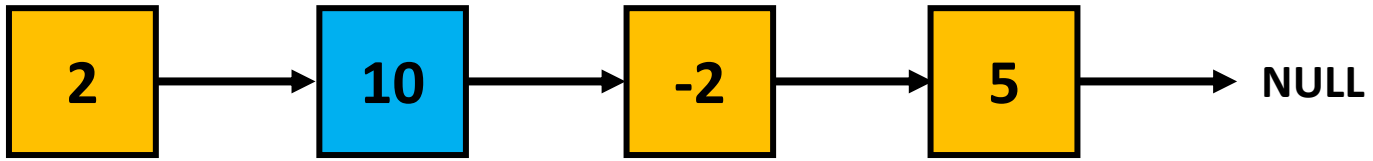

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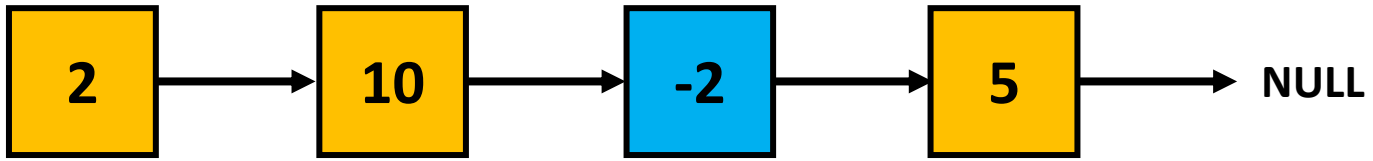

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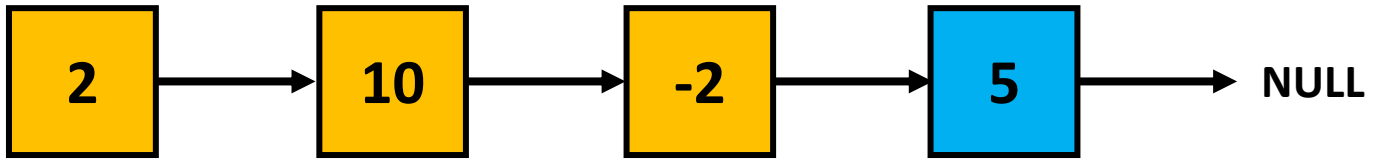

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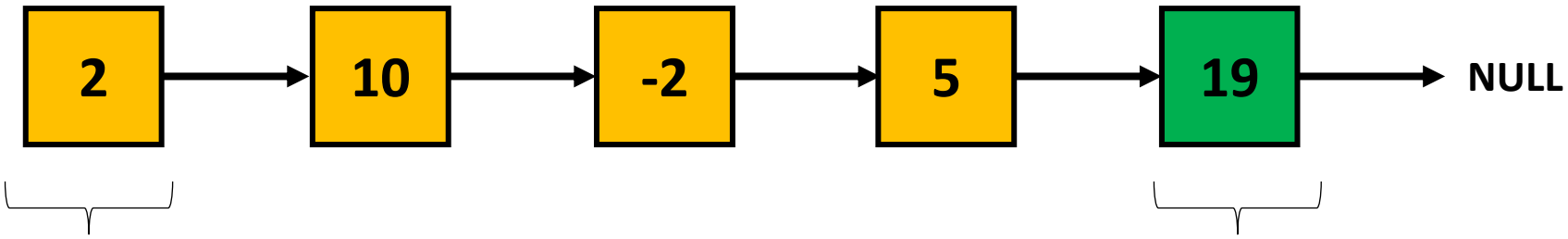

we can access the head node exclusively - so we have to start here always -

we have to find the item we want to remove (linear search) in ***O(N)*** *running time*

Linked Lists Operations

Manipulation the first item (insertion or removal):

O(1) running time – this is why we like linked lists

Manipulating arbitrary item

O(N) running time – if we have to do several of these operations then linked list is not the best option possible !!!

Linked Lists Advantages

- linked lists are **dynamic data structures**: they can acquire memory at *run-time* by inserting new nodes
- no need for resizing the data structures – as we have seen with arrays
- we can grow the data structure organically – not a problem if we do not know the size at *compile-time*
- manipulating the first item is fast – **O(1)** running time
- can store different sized items – arrays assume the items have the exact same size

Linked Lists Disadvantages

- need **more memory** because of the references
- there is no random access - we can only access the first node (*head node*) of the linked list
- can not go backwards – how to get the previous node?
- **not predictable** – the running time of the application relies heavily on the operations the users do
- still have not solved the main issue – how to search for arbitrary items faster than **O(N)** linear running time?