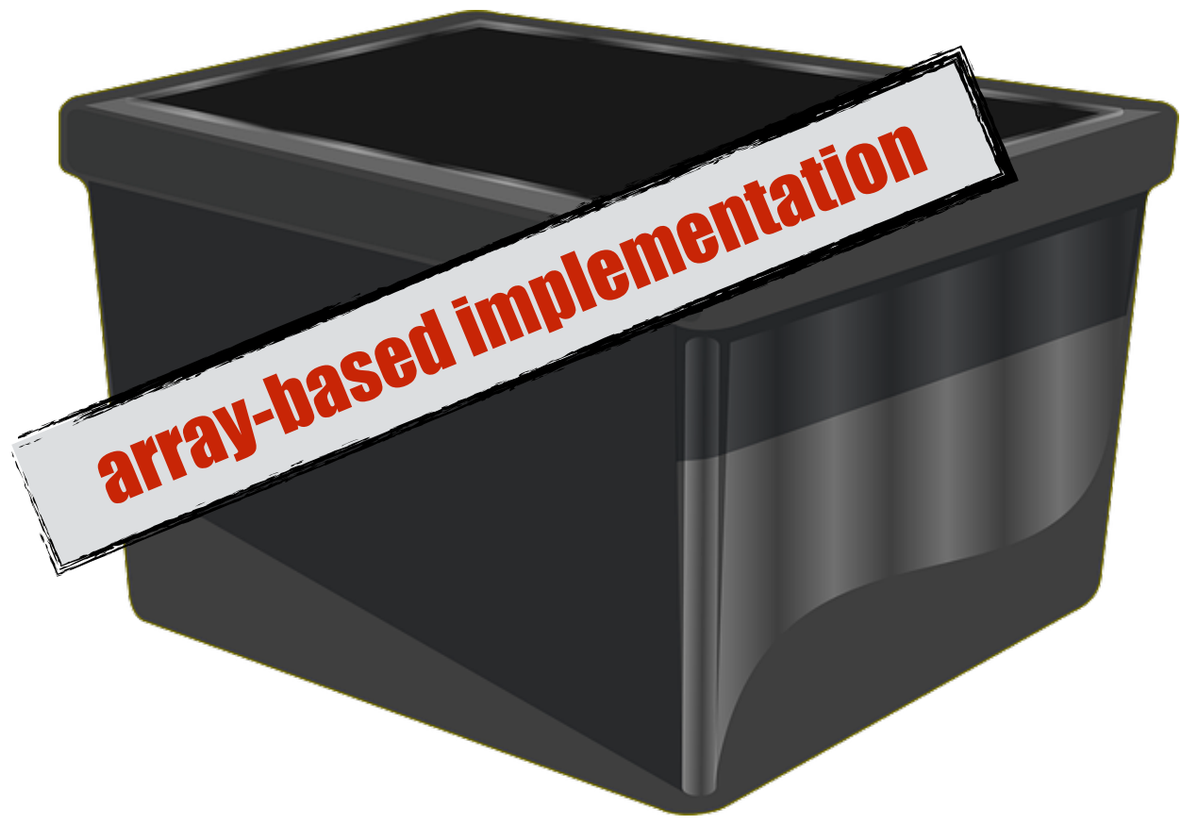
Prepared by Julian García, based on material by
David Albrecht and María García de la Banda

Lecture 18
Linked Stacks

FIT 1008
Introduction to Computer Science

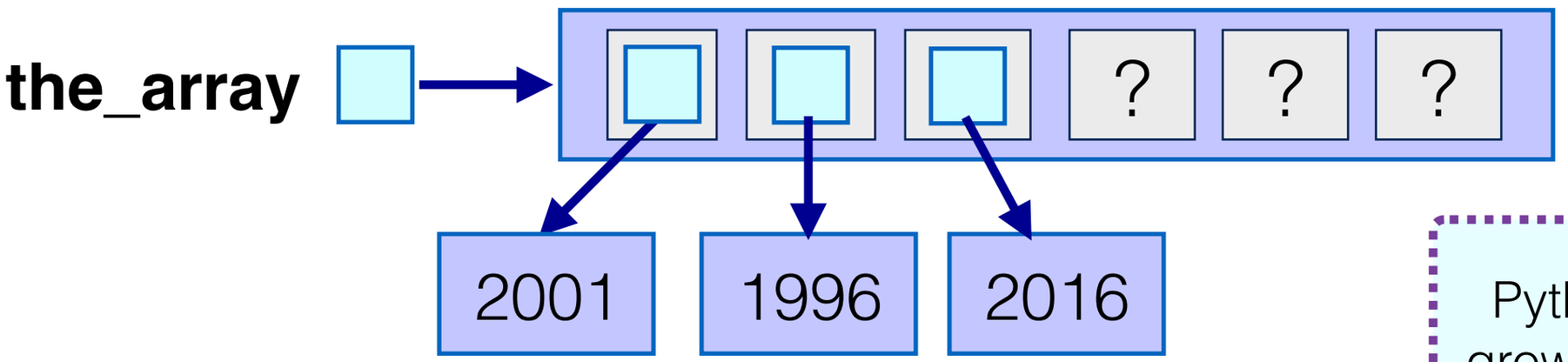
Container ADTs

- **Stores** and **removes** items **independent of contents.**
- **Examples** include:
  - List ADT ☑
  - Stack ADT ☑
  - Queue ADT. ☑
- Core **operations**:
  - ➡ add item
  - ➡ remove item



Array implementation

- Array **characteristics**:
  - Fixed size
  - Data items are stored sequentially
  - Each item occupies exactly the same amount of space

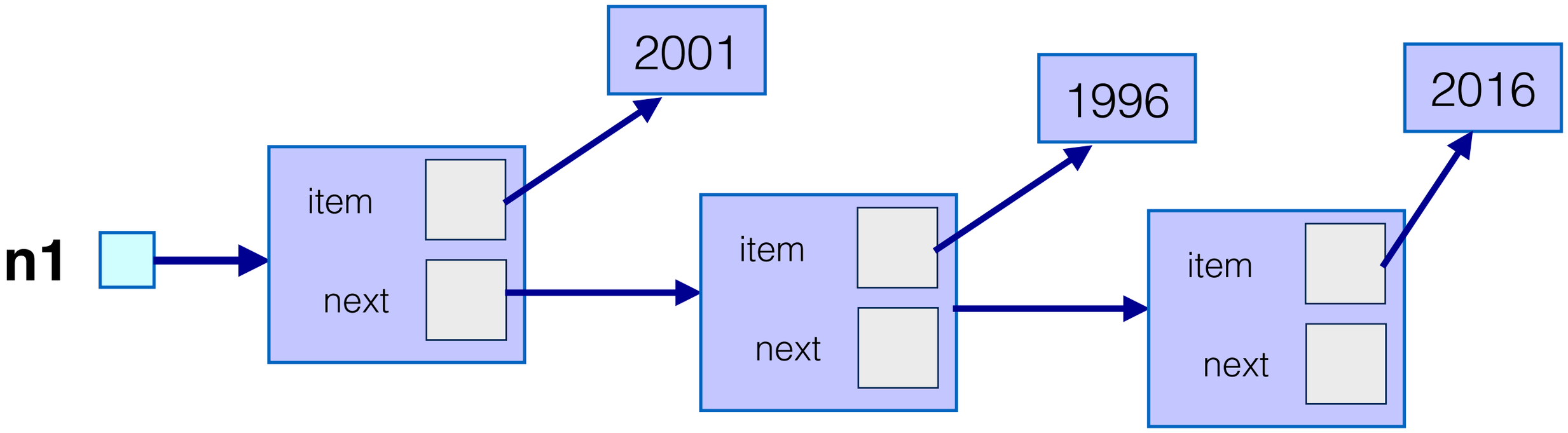


Python lists: array growth pattern is 0, 4, 8, 16, 25, 35, 46, 58, 72, 88,…

- Main **advantages**:
  - Very **fast** access O(1)
  - Very **compact** representation if the array is full

- Main **disadvantages**:
  - Non-resizable: maximum size specified on creation
  - Changing size is costly: **create a new array + copy all items**
  - Slow operations if shuffling elements is required

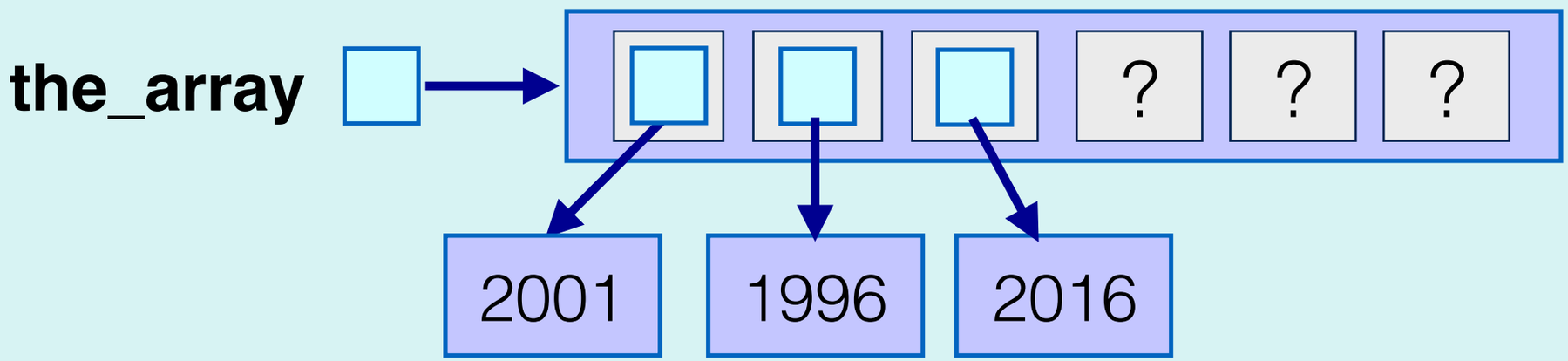
Linked Data Structures



- Collection of nodes

- Each node contains:
  - One or more **data items**
  - One or more **links to other nodes**

Array-based Data Structures:



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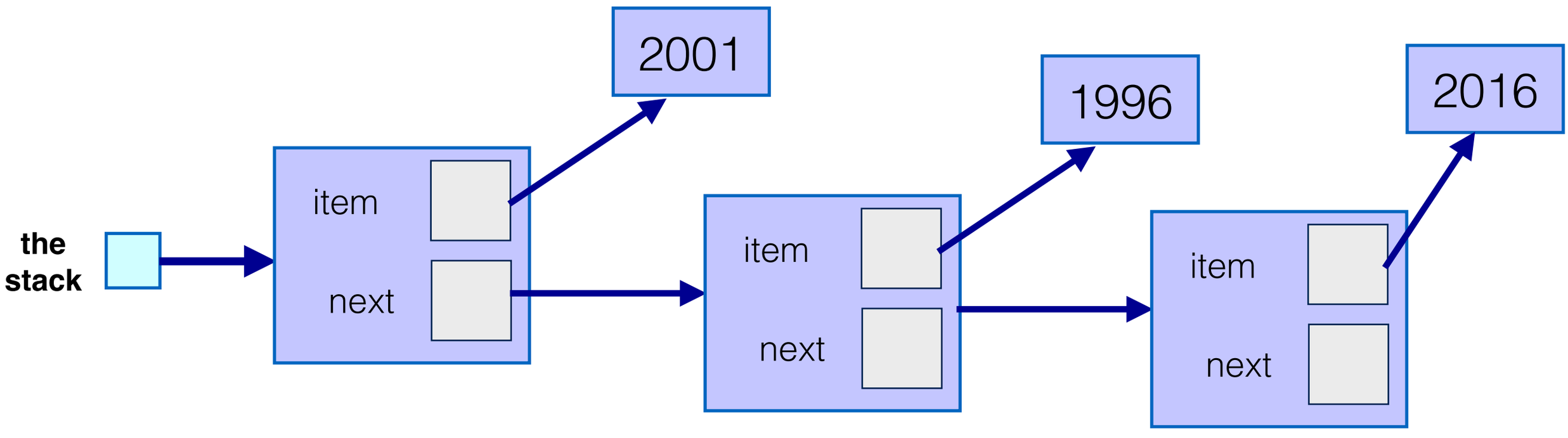
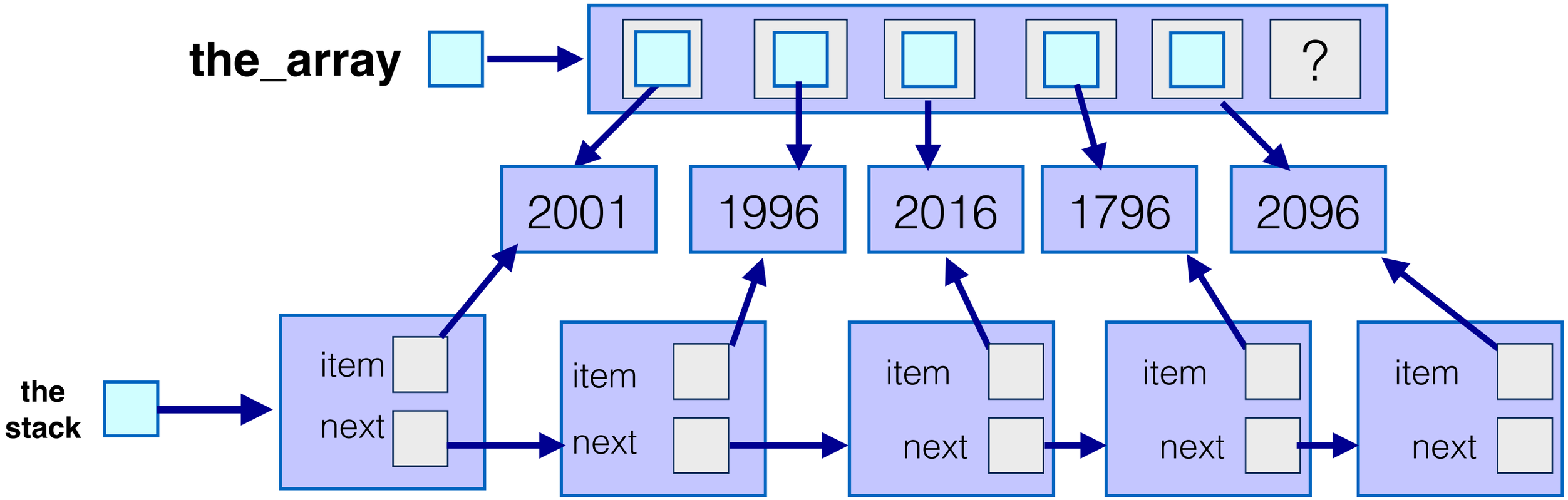


Linked Data Structures: **Advantages**

- **Fast** insertions and deletions of items (no need for reshuffling)
- Easily **resizable**: just create/delete node
- Never full (only if no more memory left)
- Less memory used than an array if the array-based implementation is relatively empty

Linked Data Structures: **Disadvantages**



- More **memory** used than an array if the array is relatively full (Reason: every data item has an associated link)

- For some data types certain operations are more time consuming (e.g., no random access)


push
pop

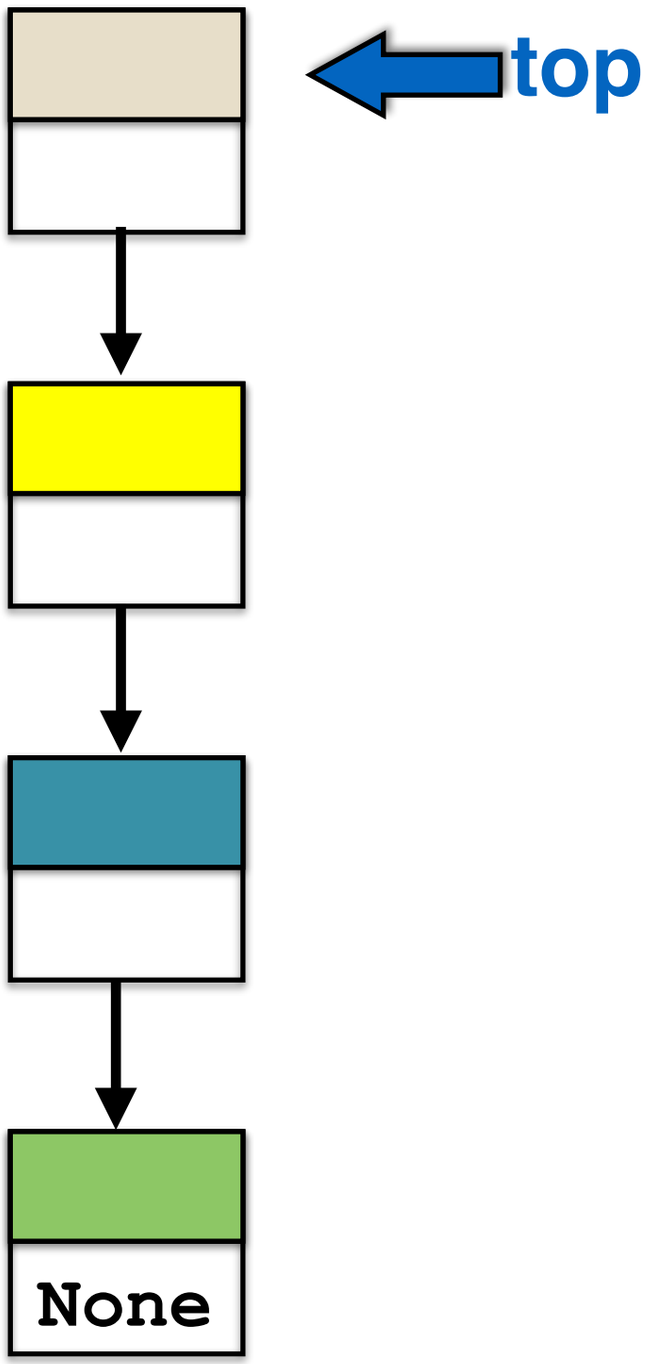
Stack Data Type

- Follows a **LIFO model**

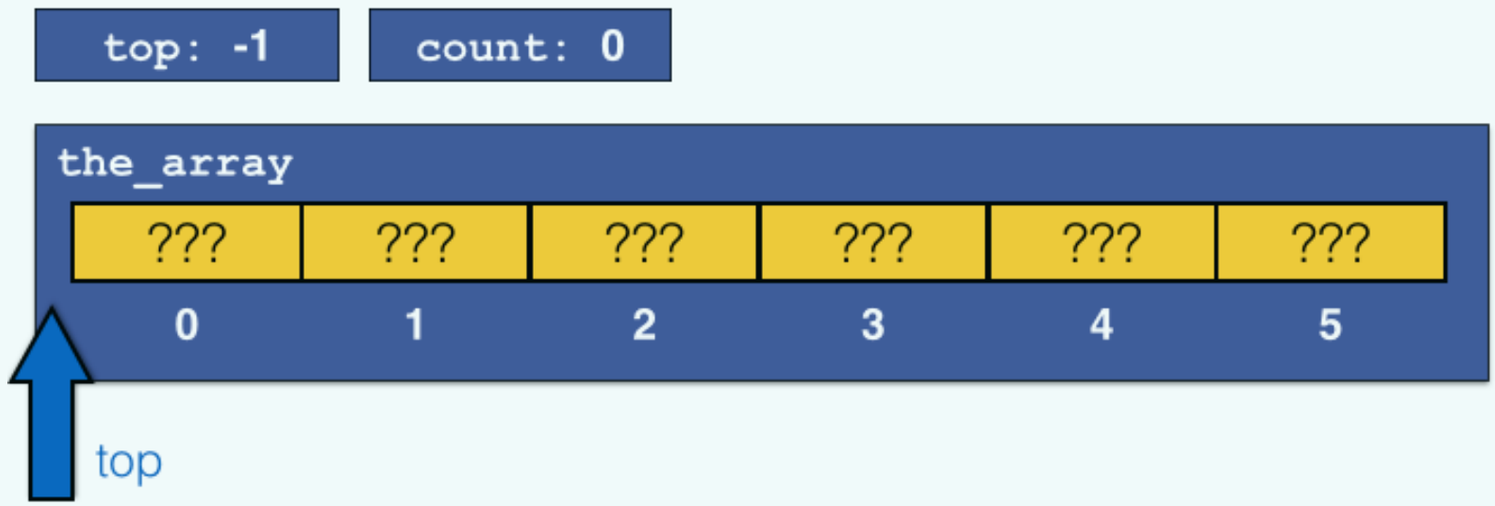
- Its **operations** (interface) are :
  - **Create** a stack (Stack)
  - Add an item to the top (**push**)
  - Take an item off the top (**pop**)
  - Look at the item on top, don't alter the stack (top/**peek**)
  - Is the stack **empty**?
  - Is the stack **full**?
  - Empty the stack (**reset**)

Remember: it only provides access to the element at the top of the stack (last element added)

Linked Stack Implementation



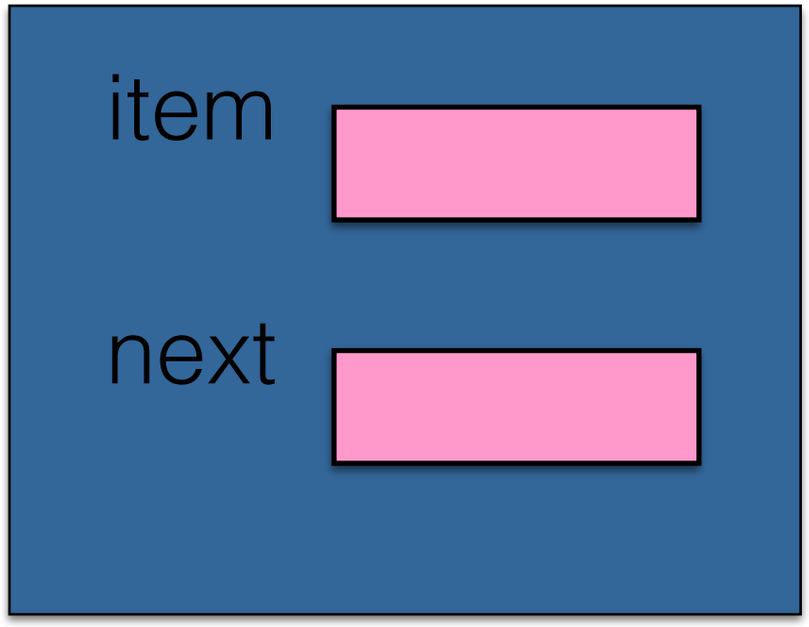
Array Stack Implementation



What do we need for a linked implementation?

Nodes!

Node




```
class Node:
    def __init__(self, item, link):
        self.item = item
        self.next = link
```

```
from node import Node


class Stack:
    def __init__(self):
        self.top = None

    def is_empty(self):
        return self.top is None

def is_full(self):
    return False

def reset(self):
    self.top = None
```

Push: algorithm

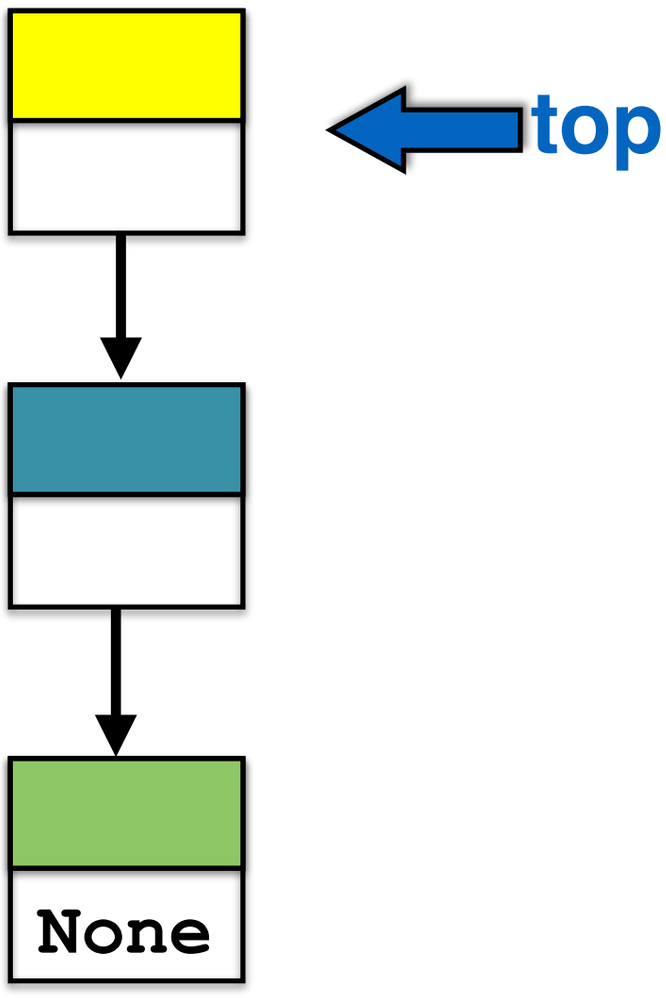
Array implementation:

- If the array is full raise exception
- Else
  - Add item in the position marked by top
  - Increase top

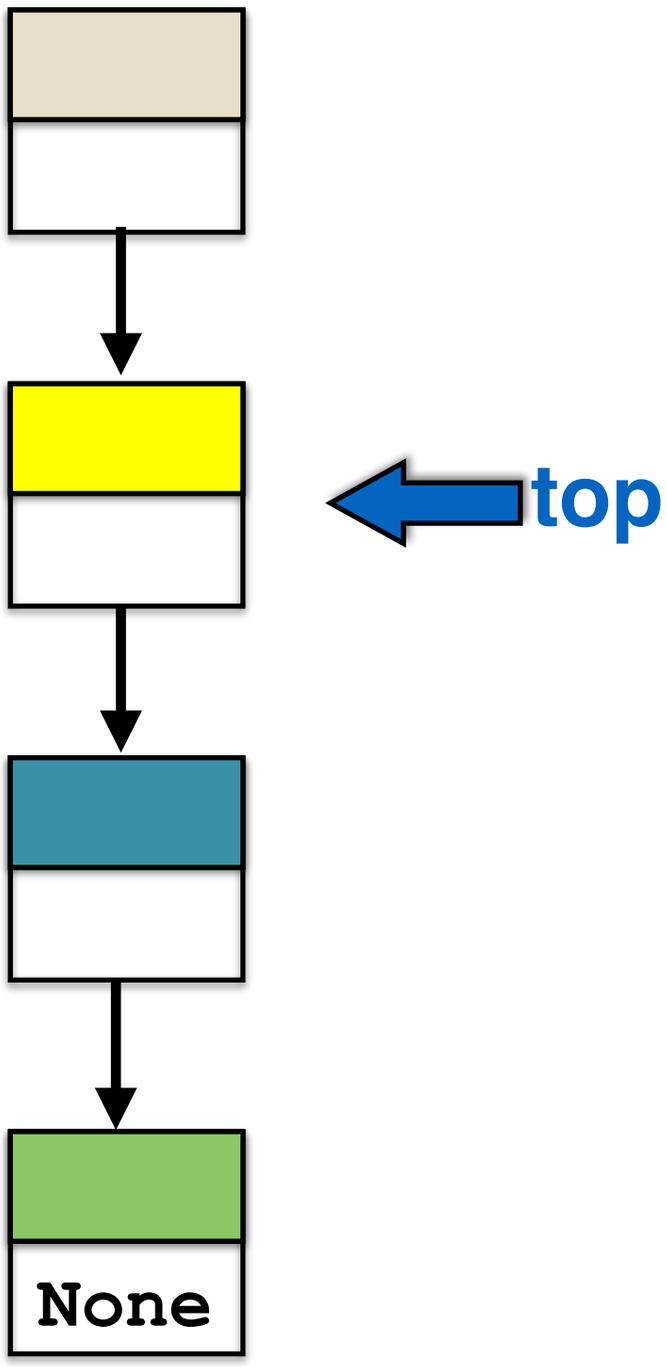
No need for is_full check.
If no more memory can be allocated the system will raise an exception.

Linked implementation:

- Create a **new node** that contains the new item and is linked to the current top
- Make the **new node** the **new top**


top
None

Create a new node with the new item.
linked to the current top



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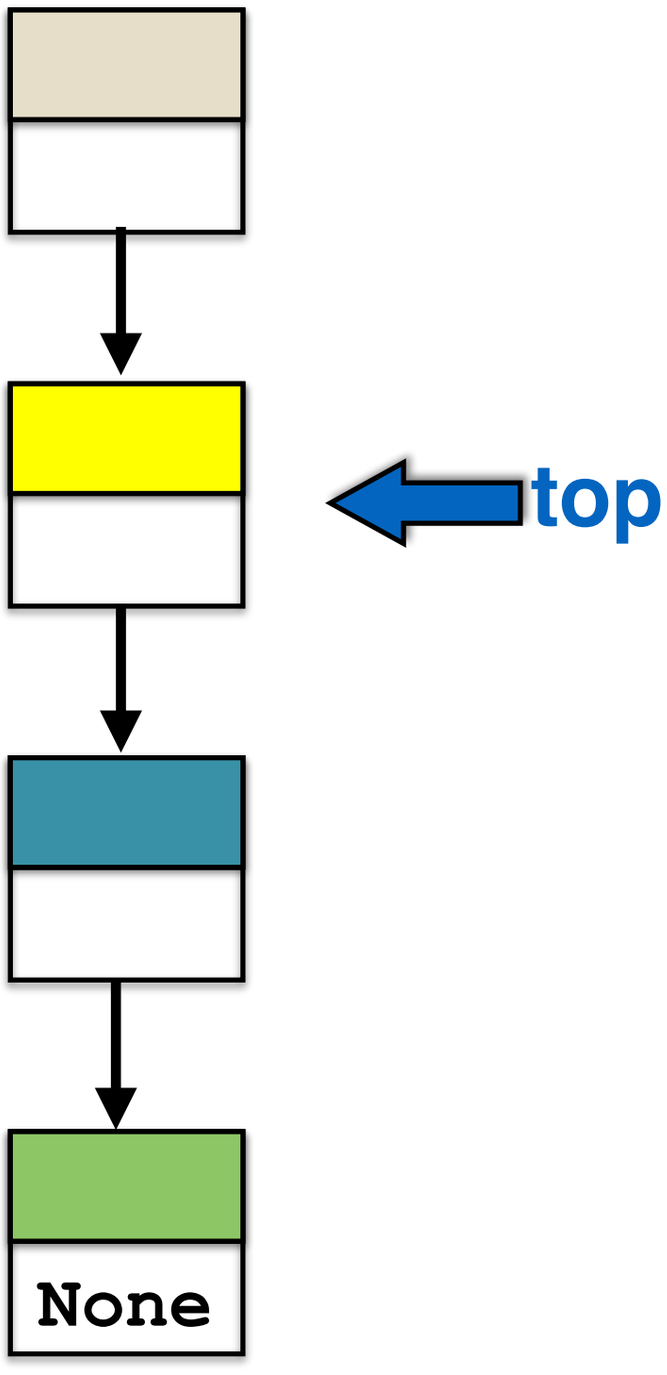
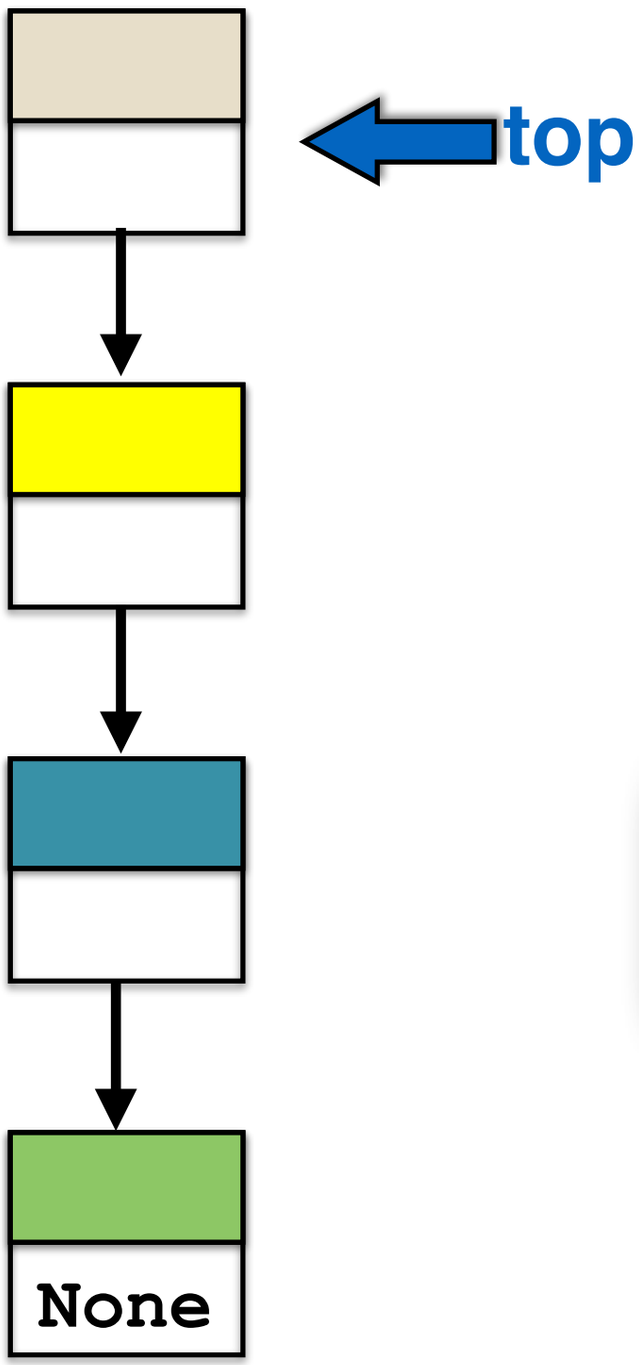
Make the new node the new **top**





Create a new node with the new item.
linked to the current top

Make the new node the new **top**

```
def push(self, item):
    self.top = Node(item, self.top)
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Consider a stack with **7** on top

`stack.push(41)`

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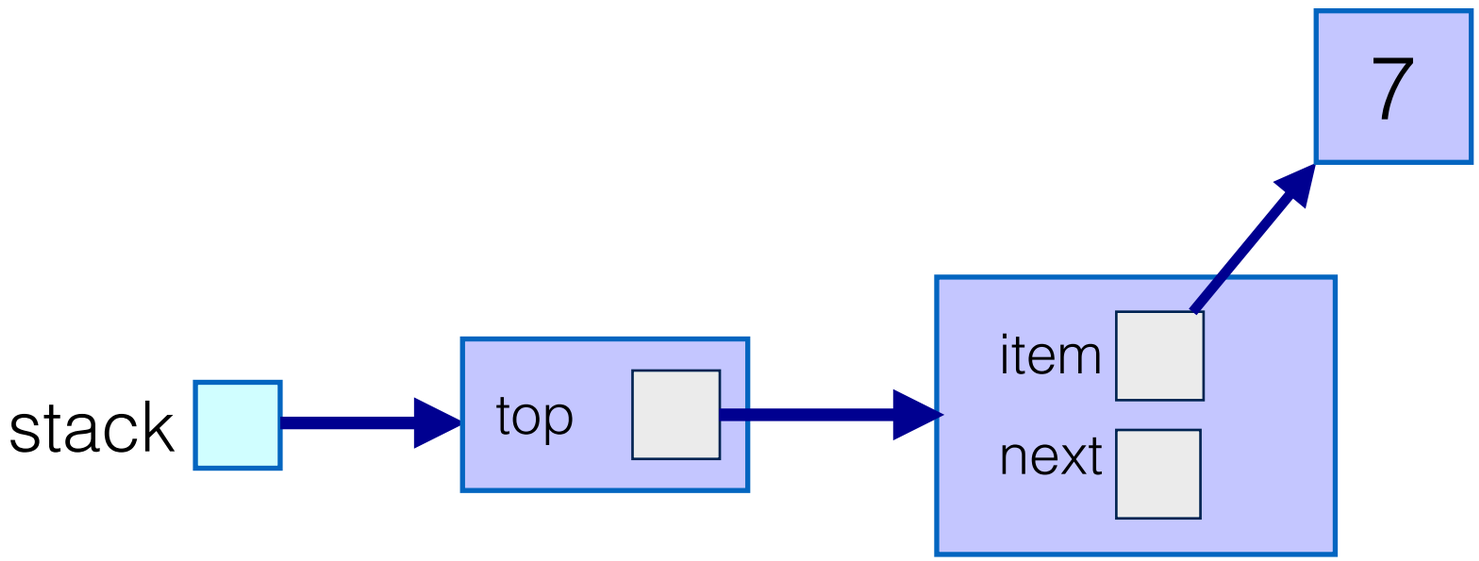

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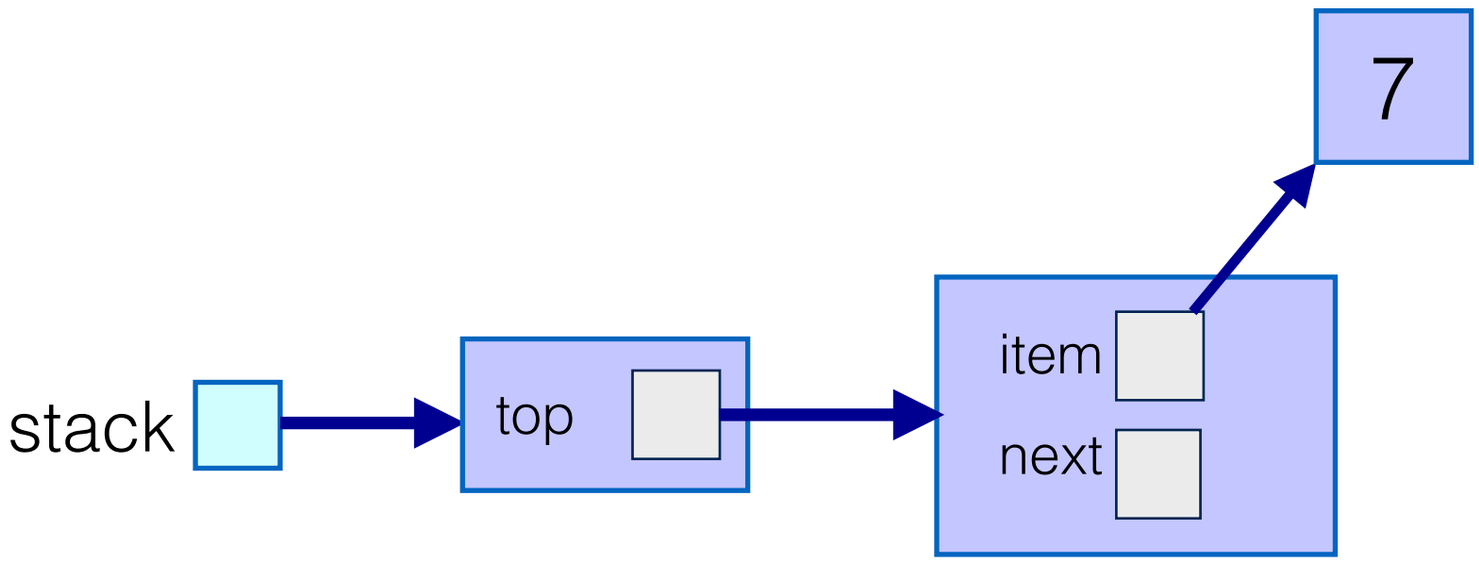

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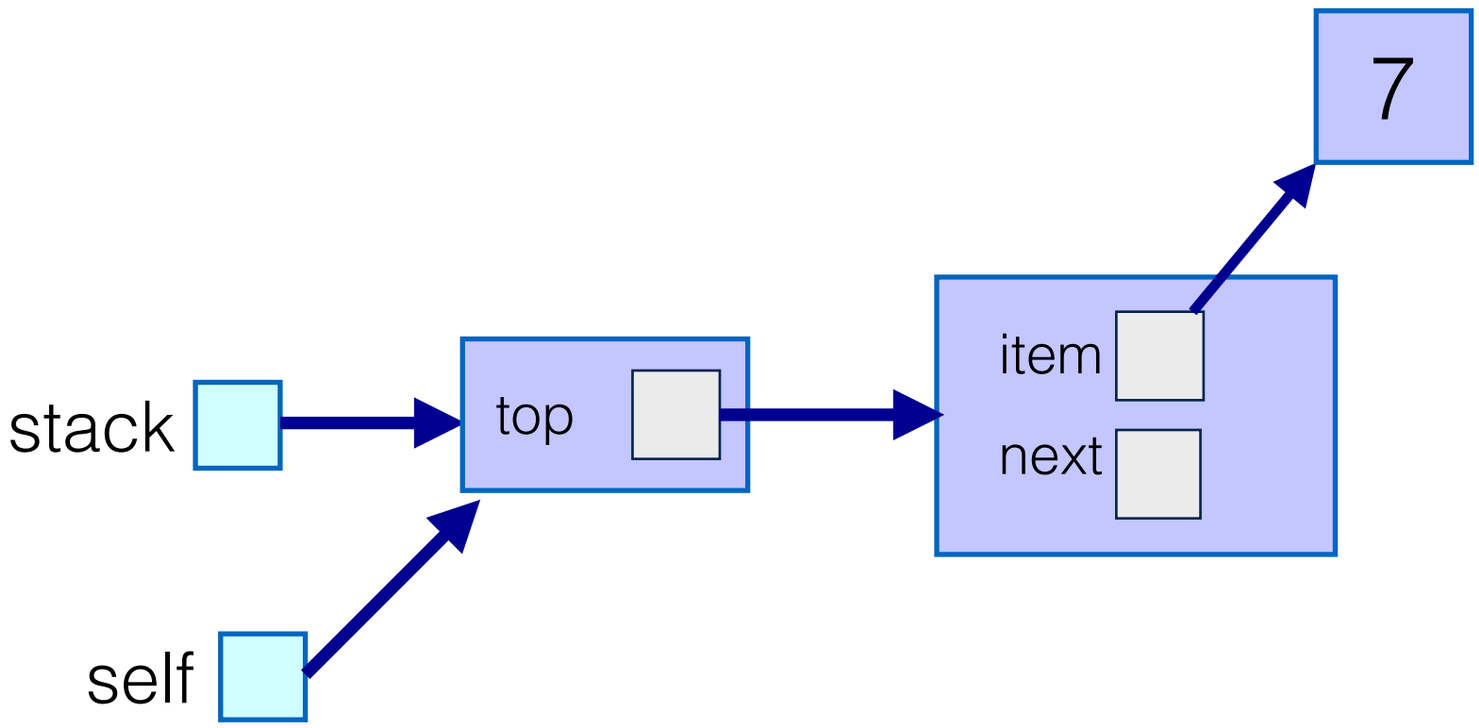

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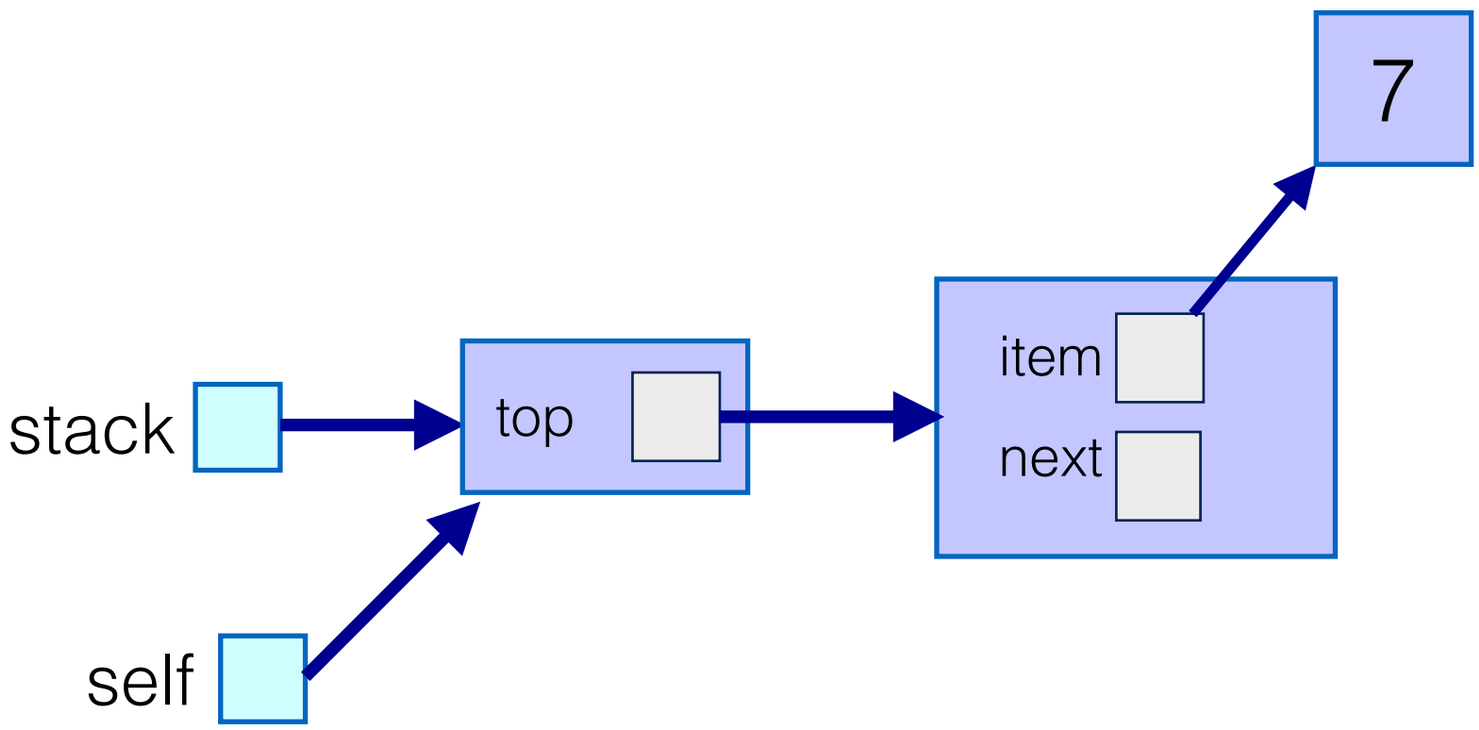

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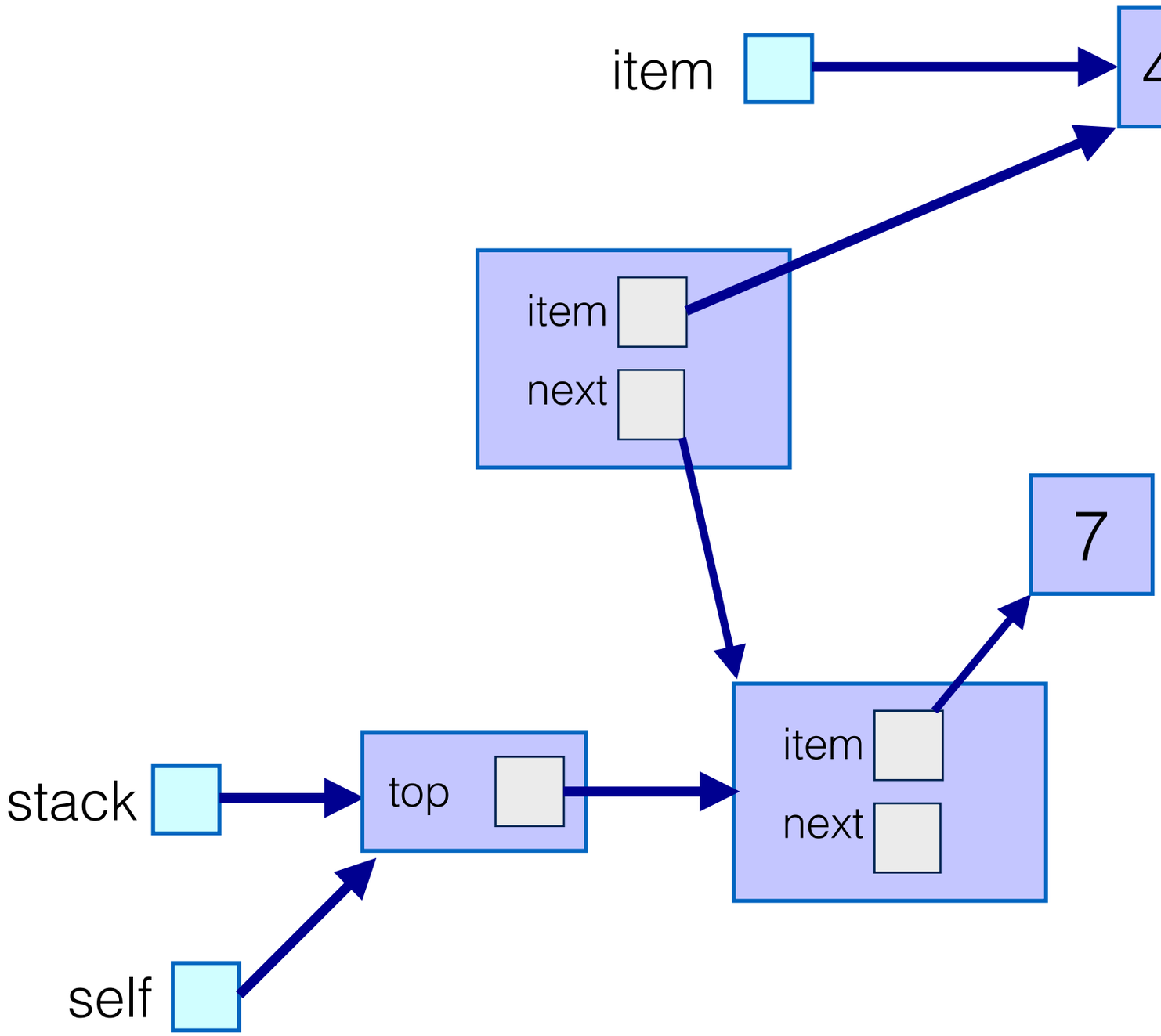

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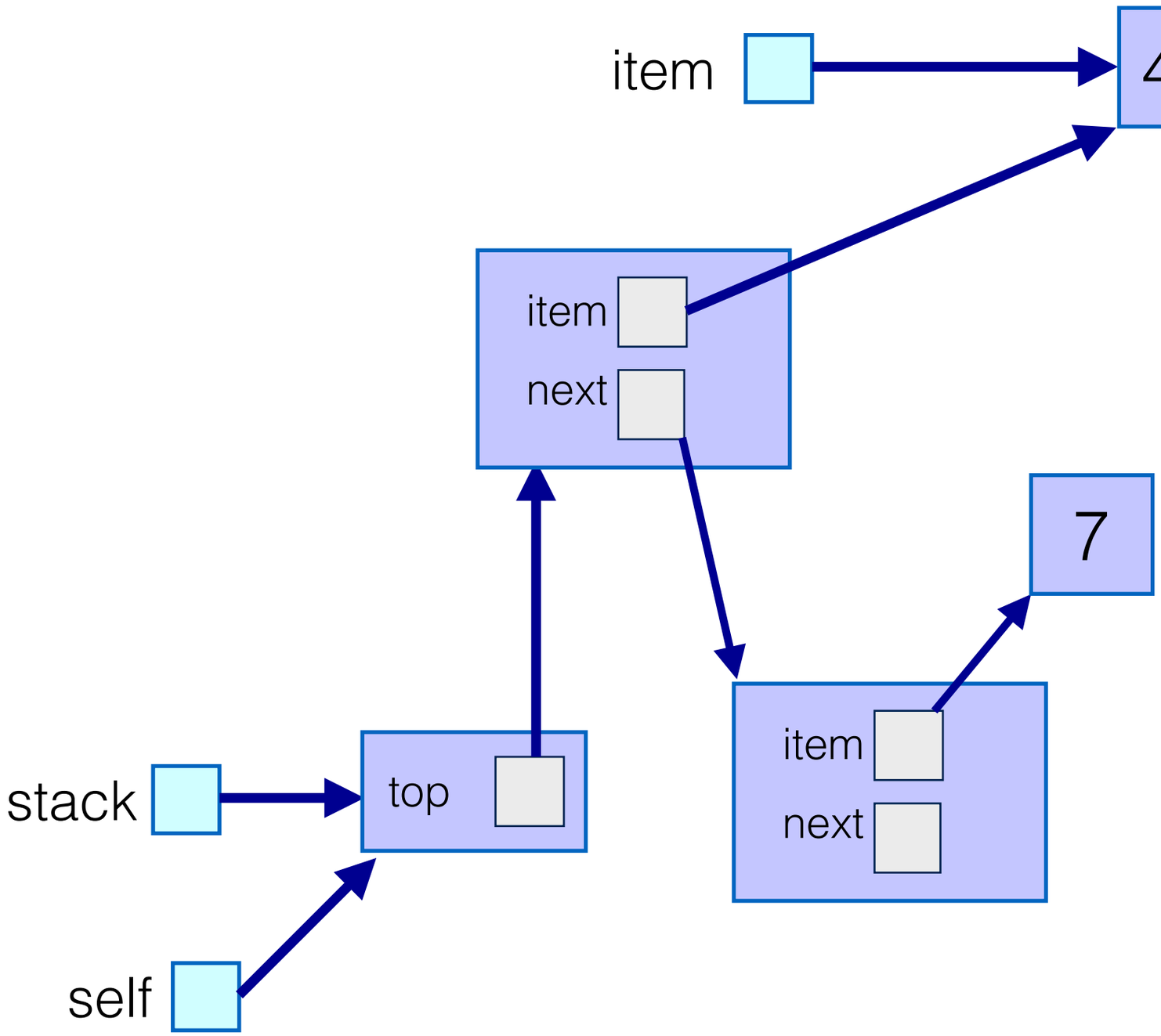

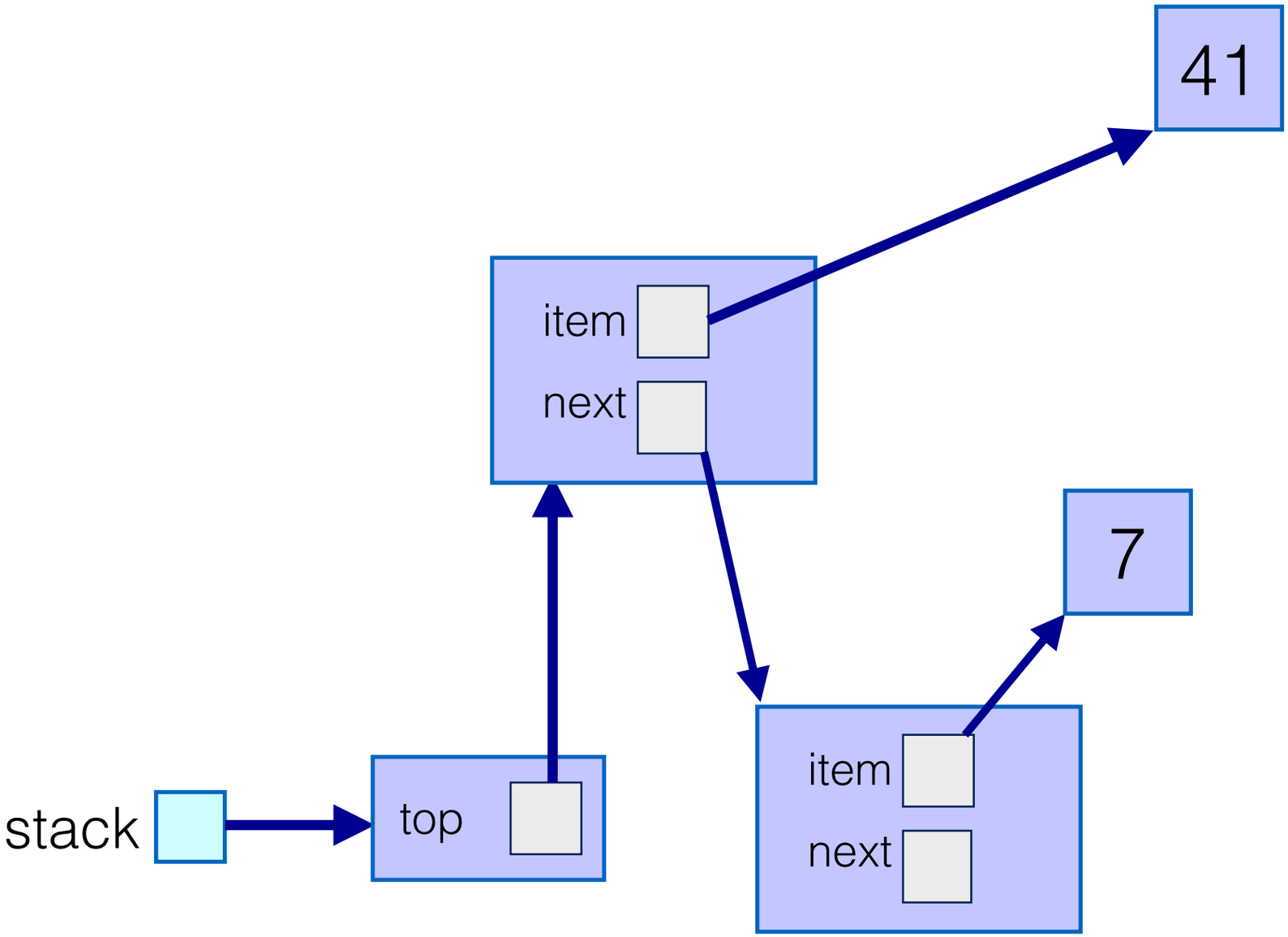
41
item
next
7
item
next
stack
top

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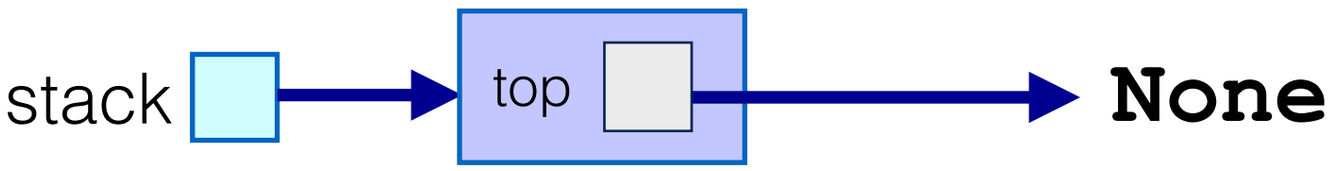

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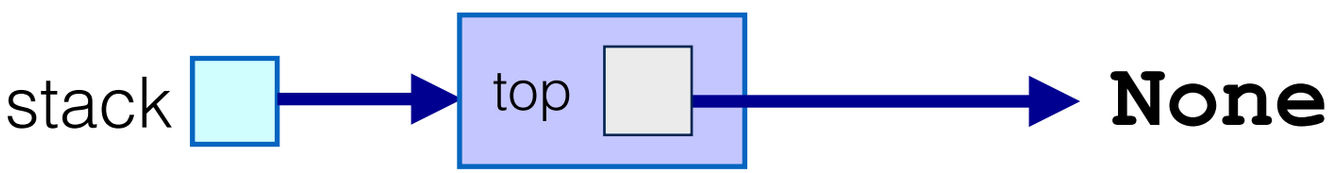

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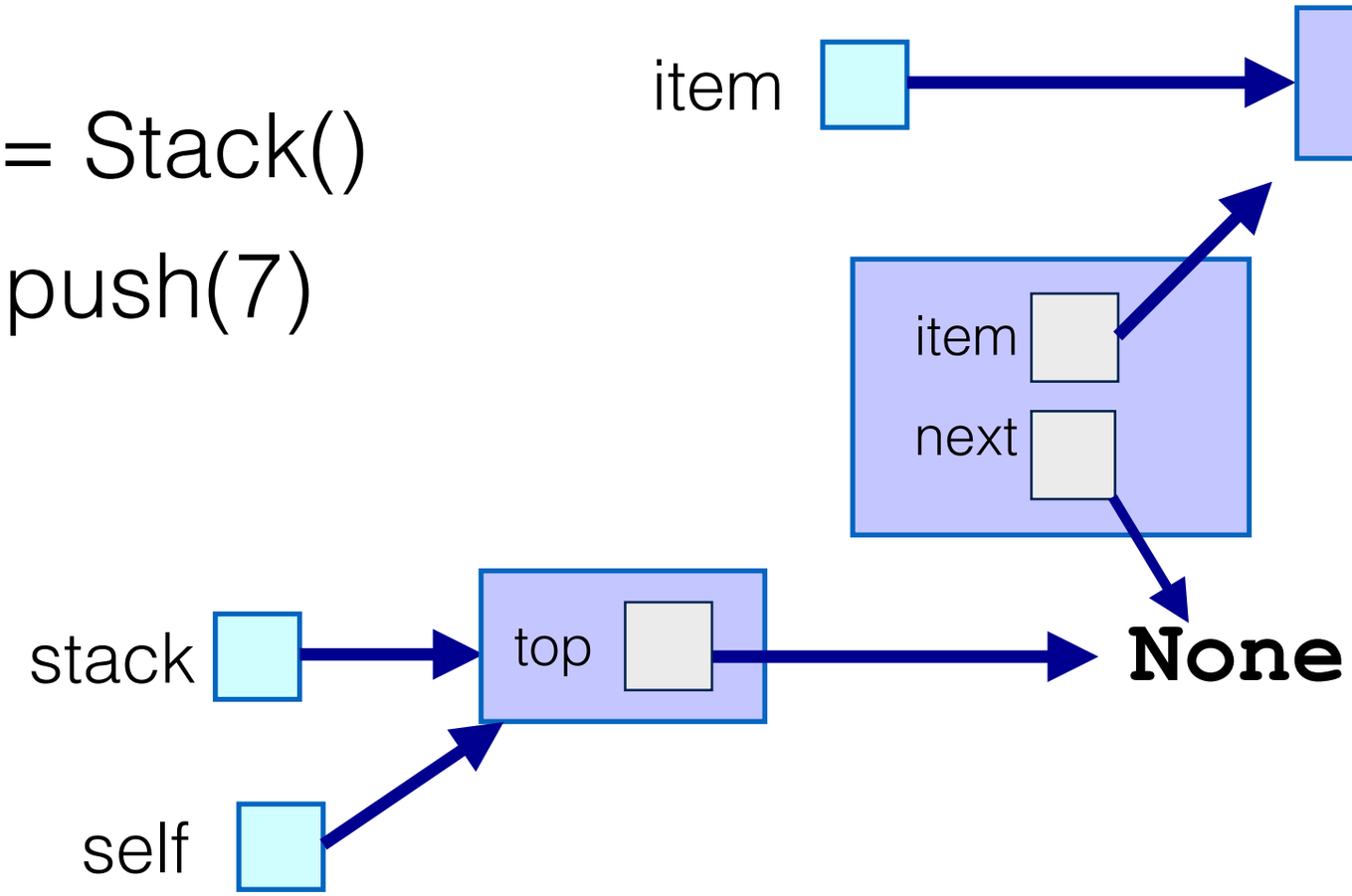

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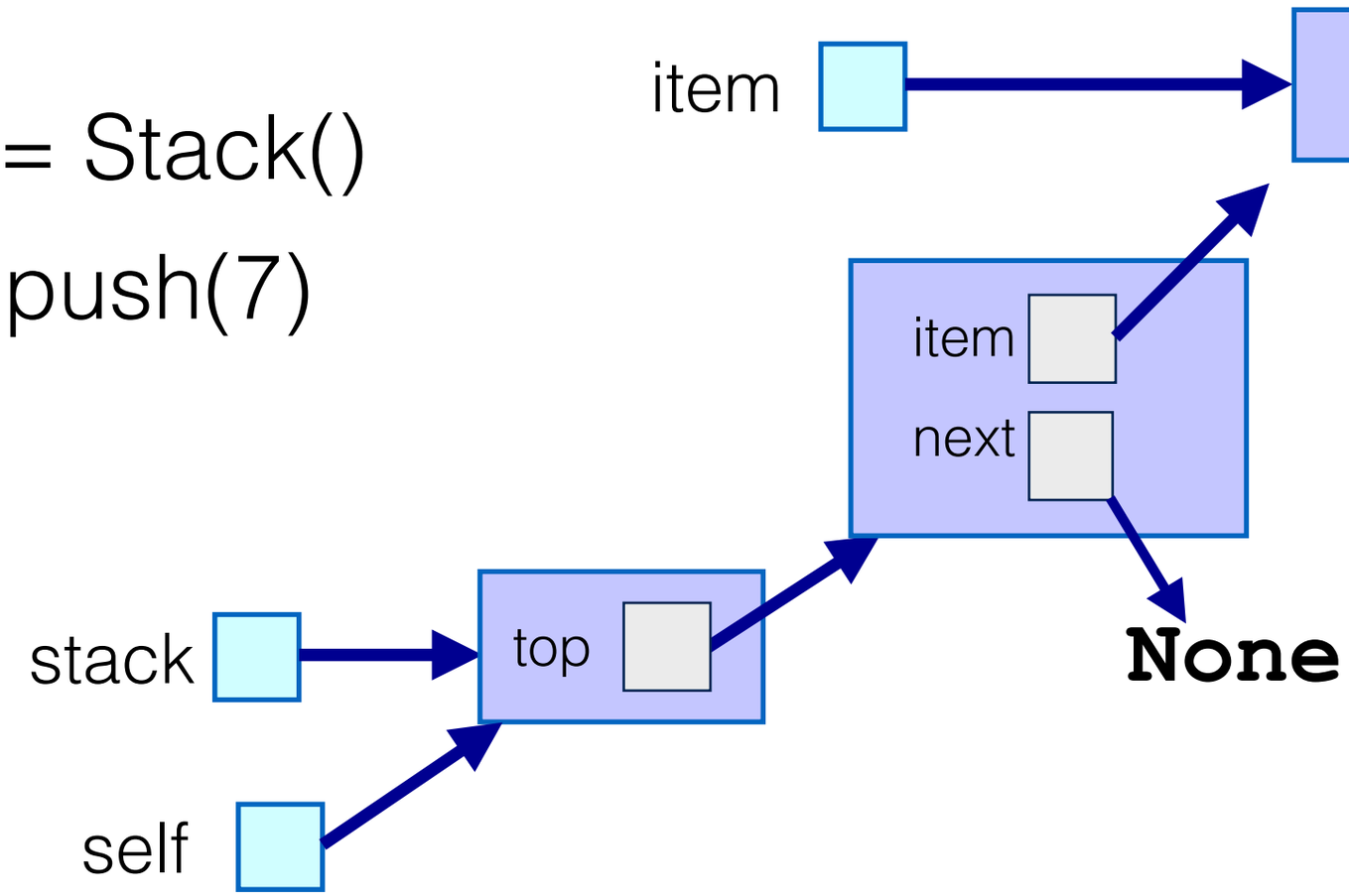

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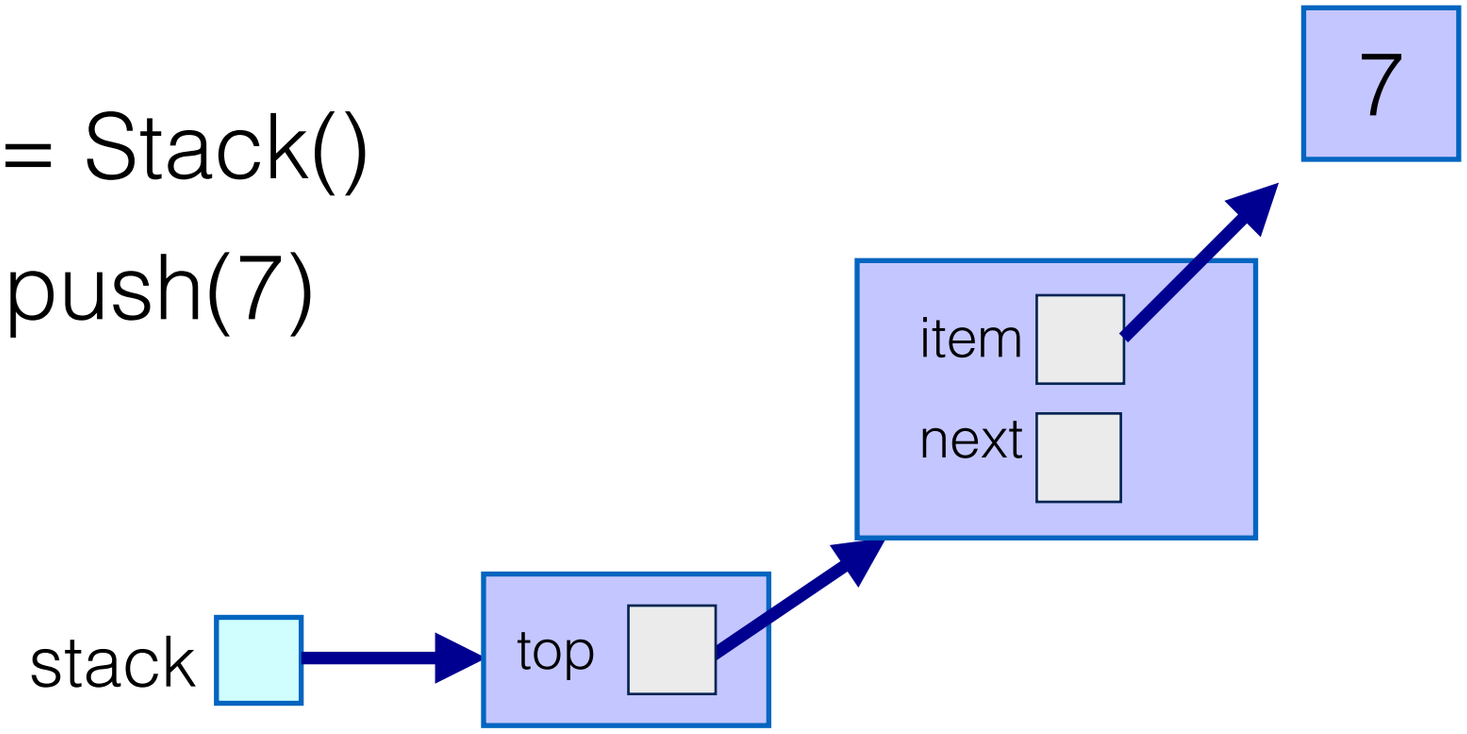

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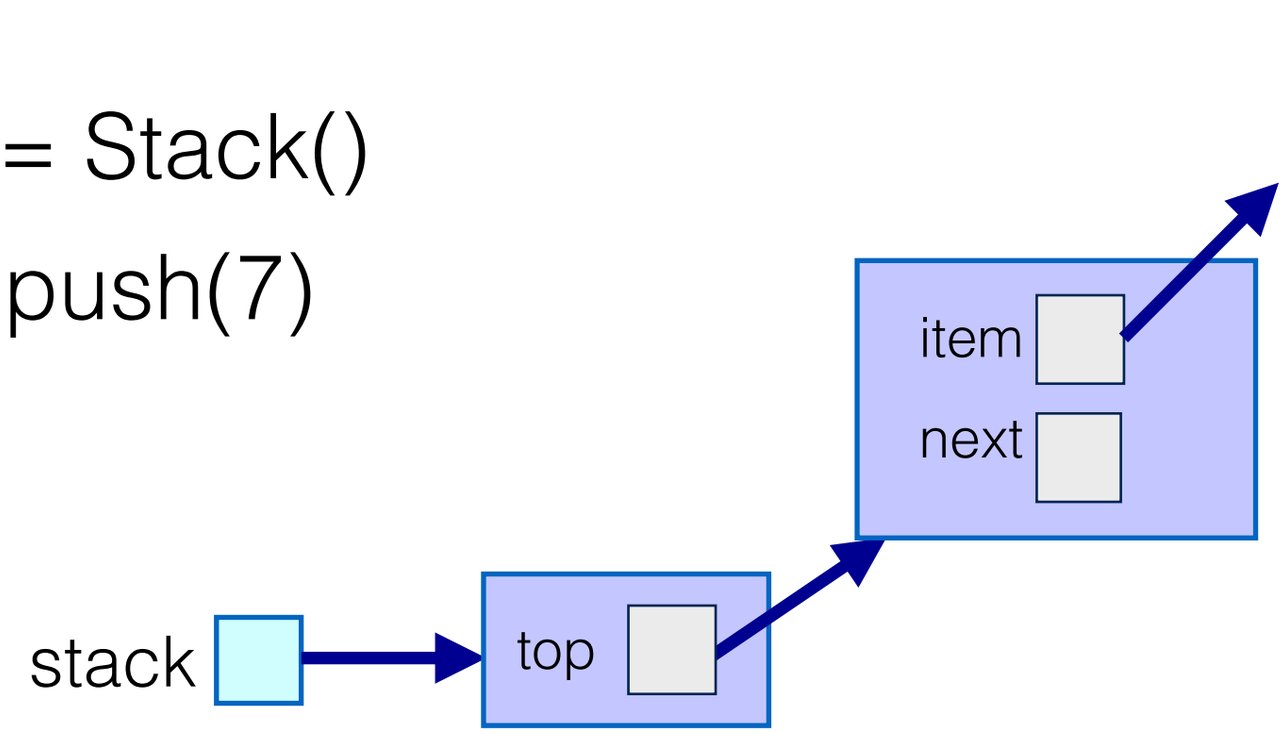
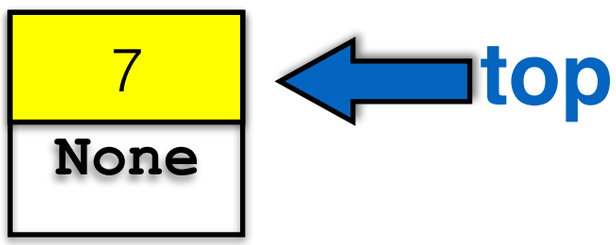




Pop: algorithm

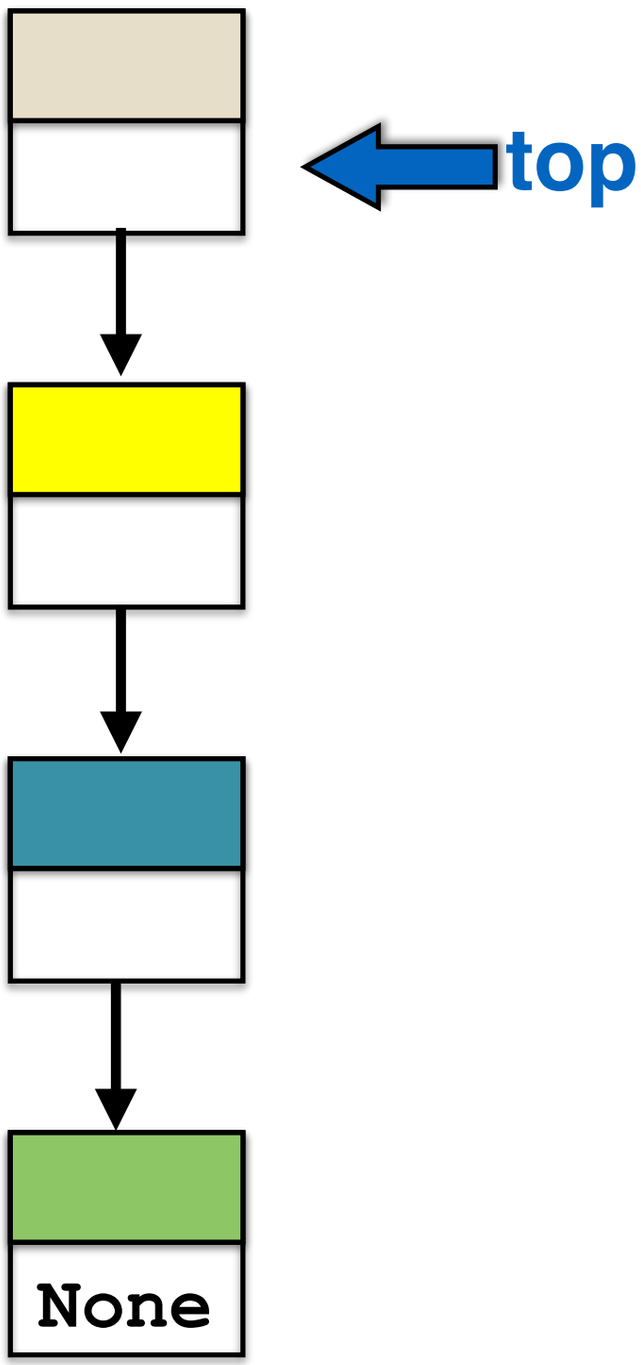
Array implementation:

- If the array is empty raise exception
- Else
  - Remember the top item
  - Decrease top
  - Return the item

Linked implementation:

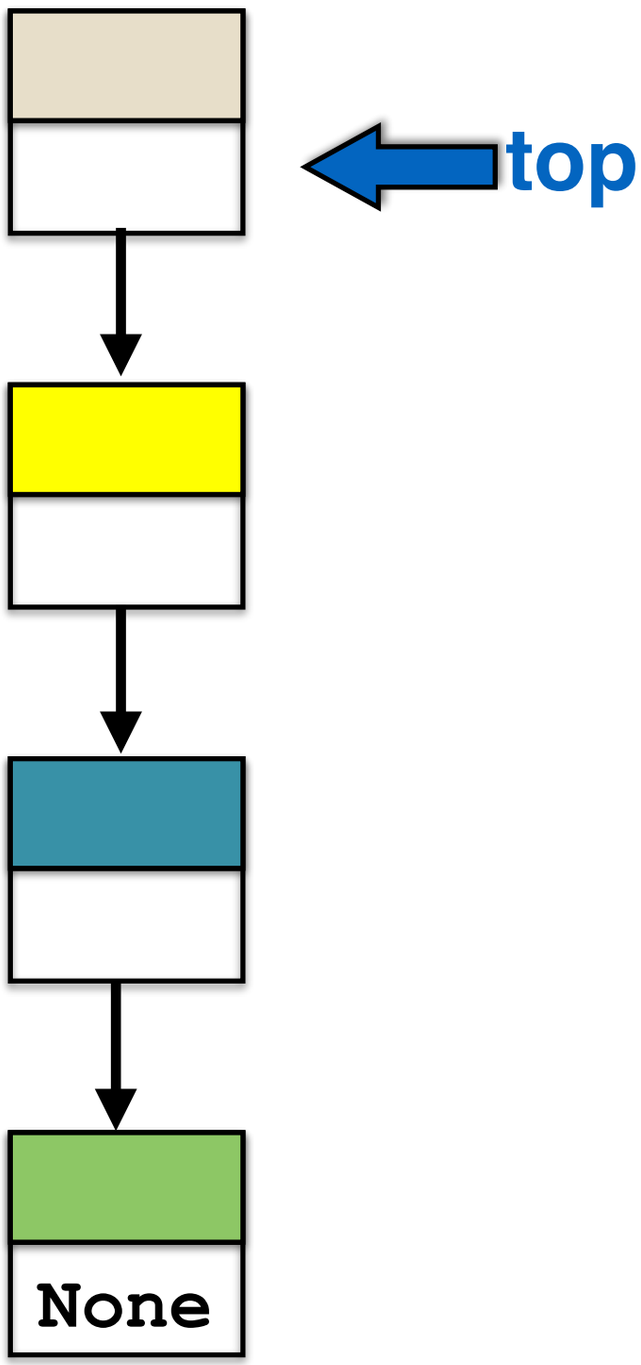
- If the stack is empty raise exception
- Else
  - Remember the top item
  - **Change top to point to the next node**
  - Return the item

Pop: algorithm



Check if the stack is empty

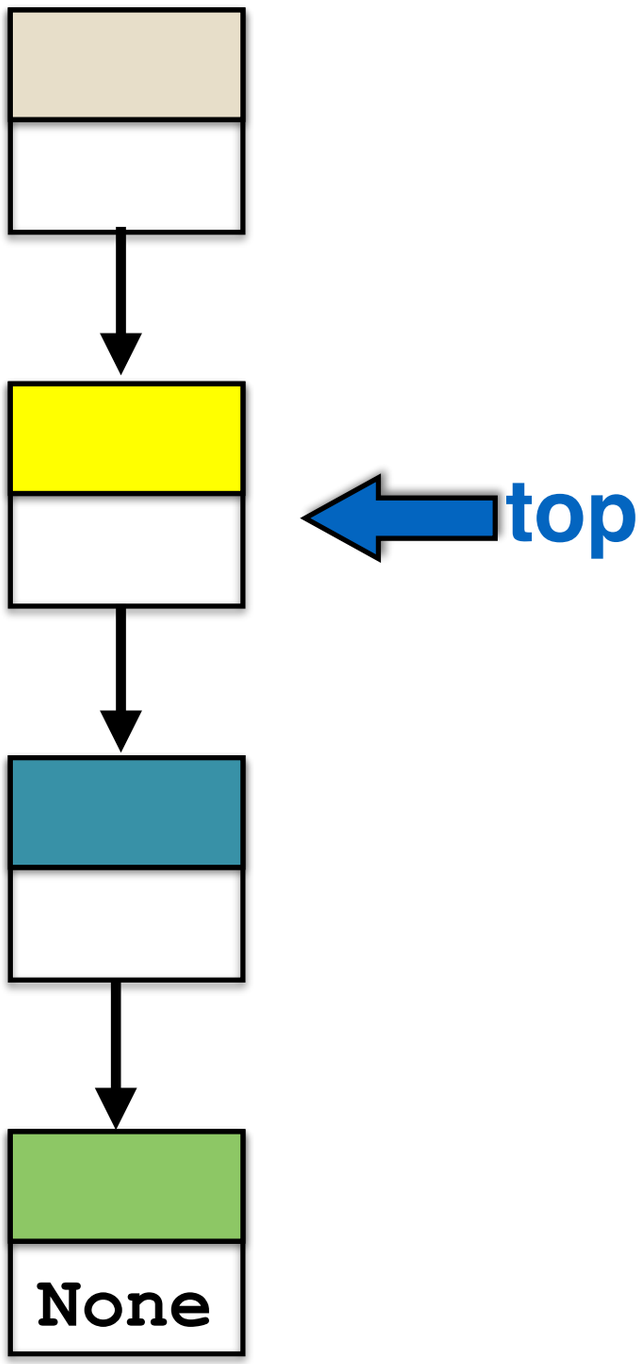
Pop: algorithm



Check if the stack is empty

Remember the item in the top node

Pop: algorithm



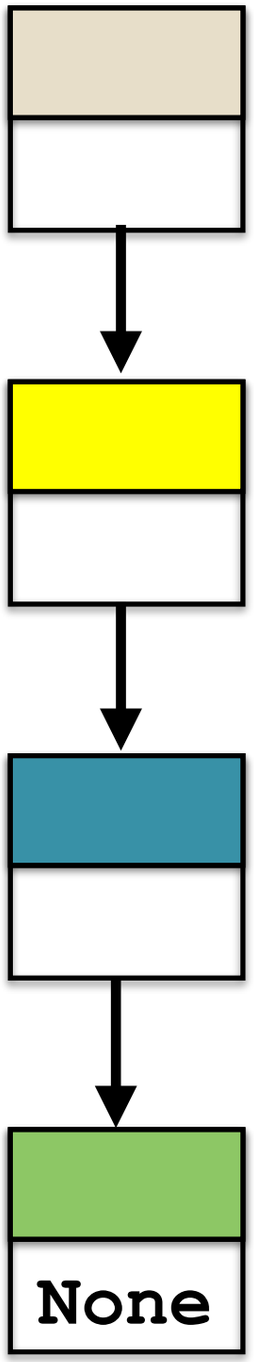
Check if the stack is empty

Remember the item in the top node

Make the next node the new top

Pop: algorithm

This node will be collected by the garbage collector



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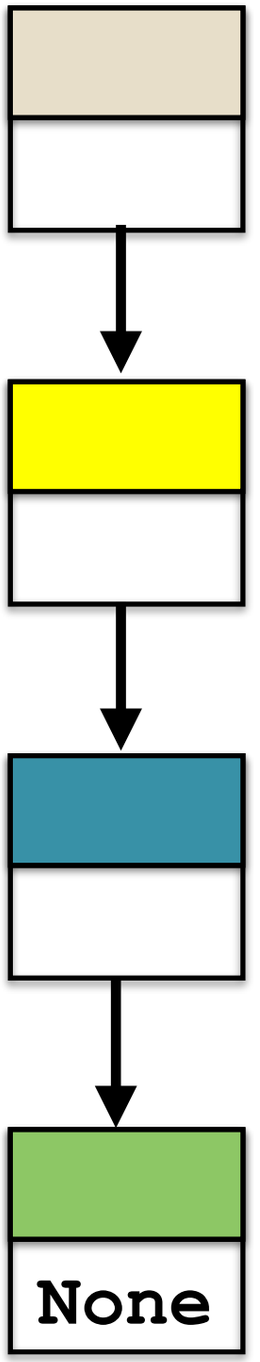

Check if the stack is empty

Remember the item in the top node

Make the next node the new top

Return the item

```
def pop(self):
    assert not self.is_empty(), "Stack is empty"
    item = self.top.item
    self.top = self.top.next
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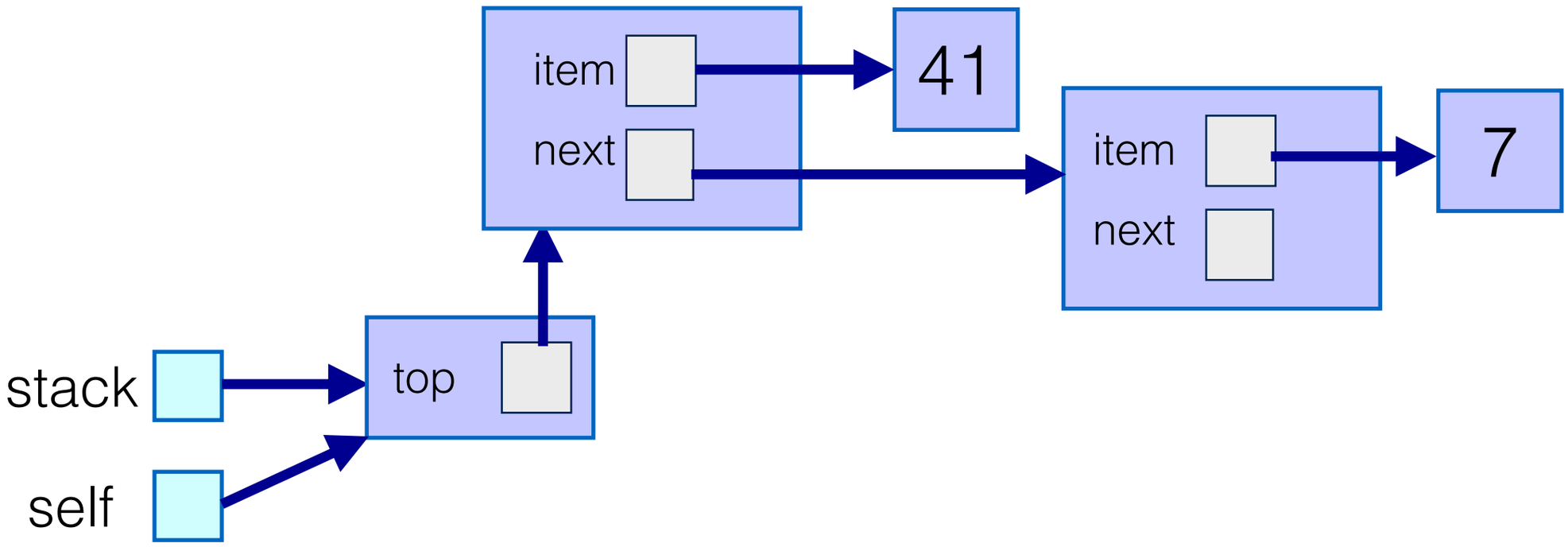

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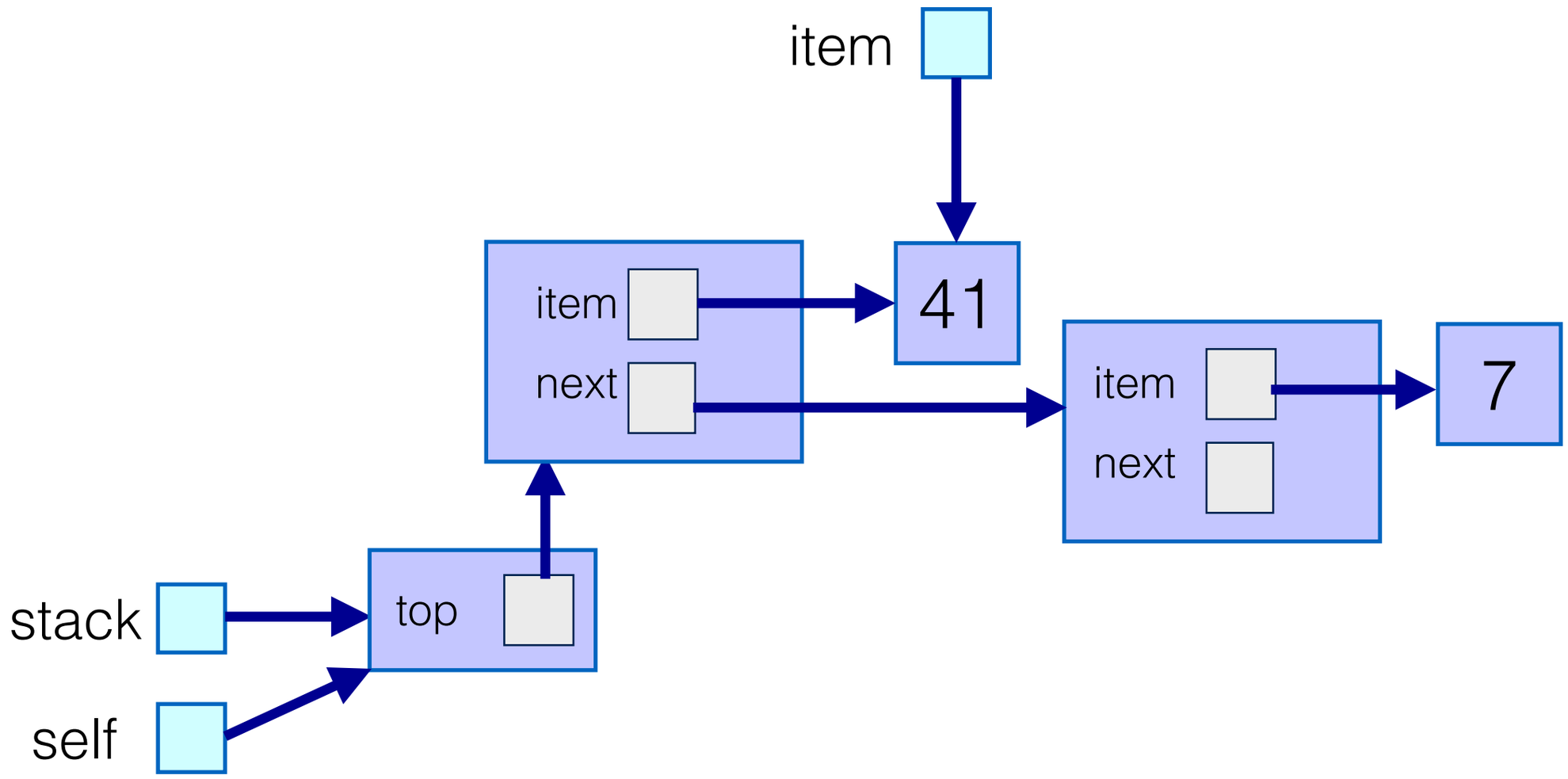

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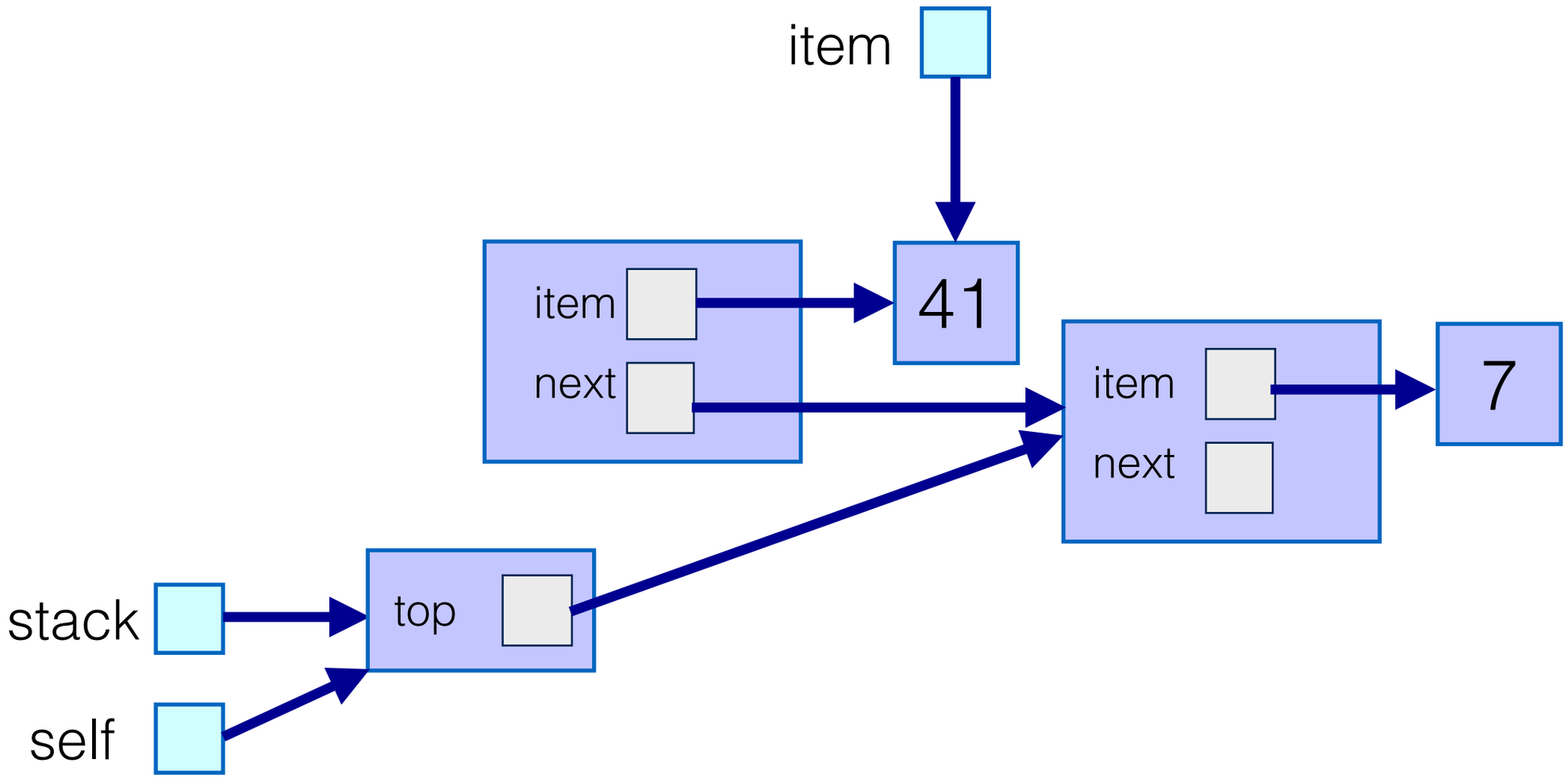

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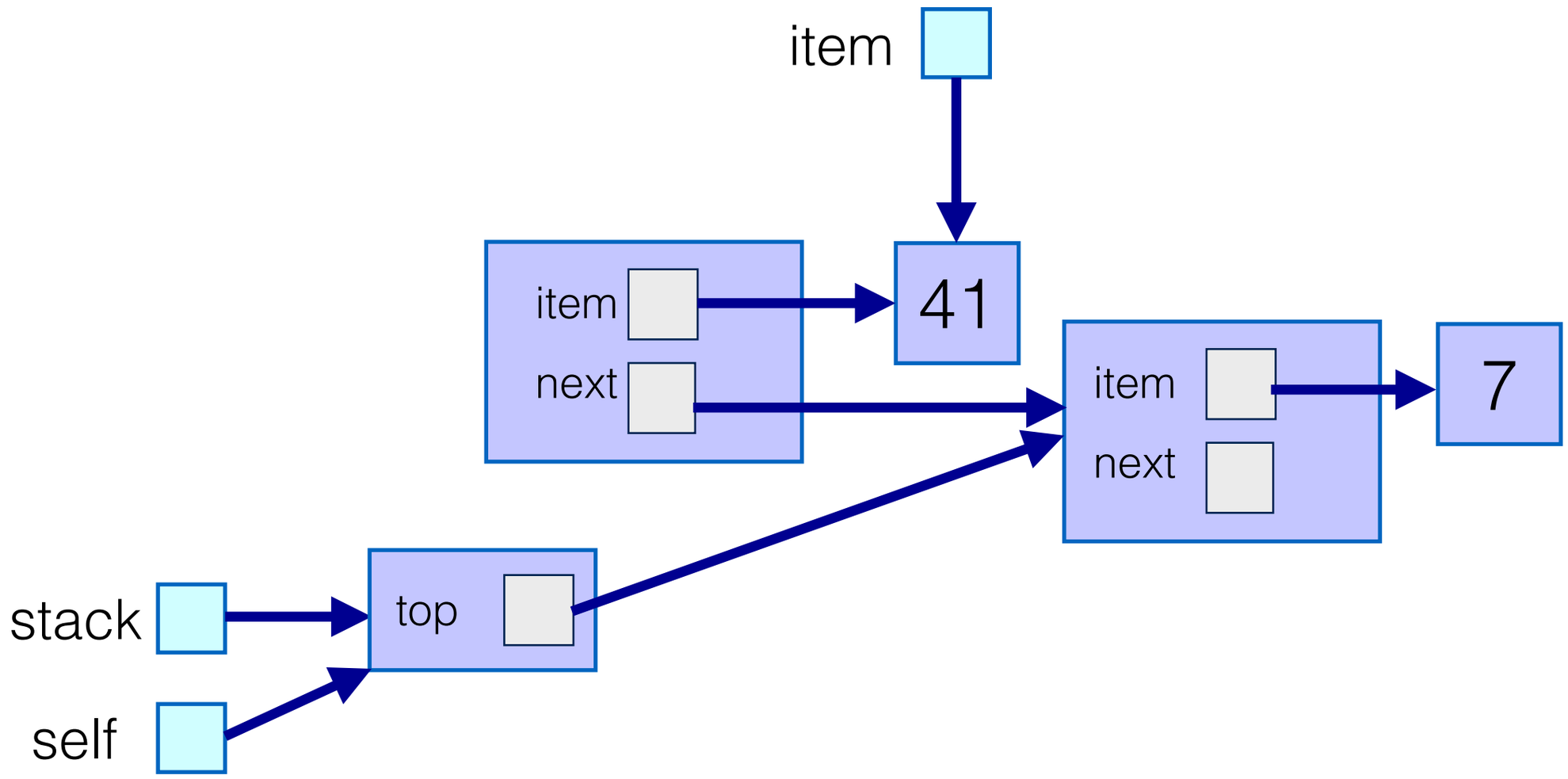

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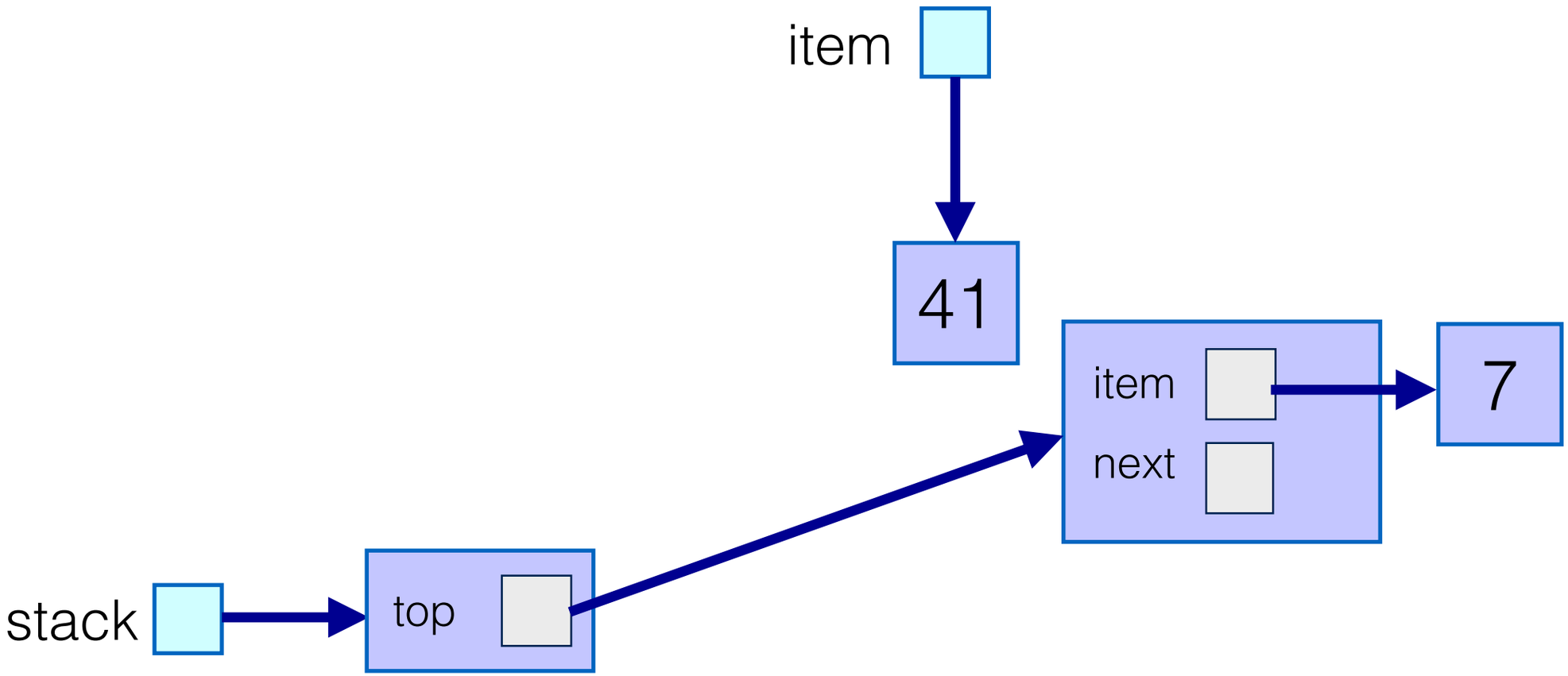

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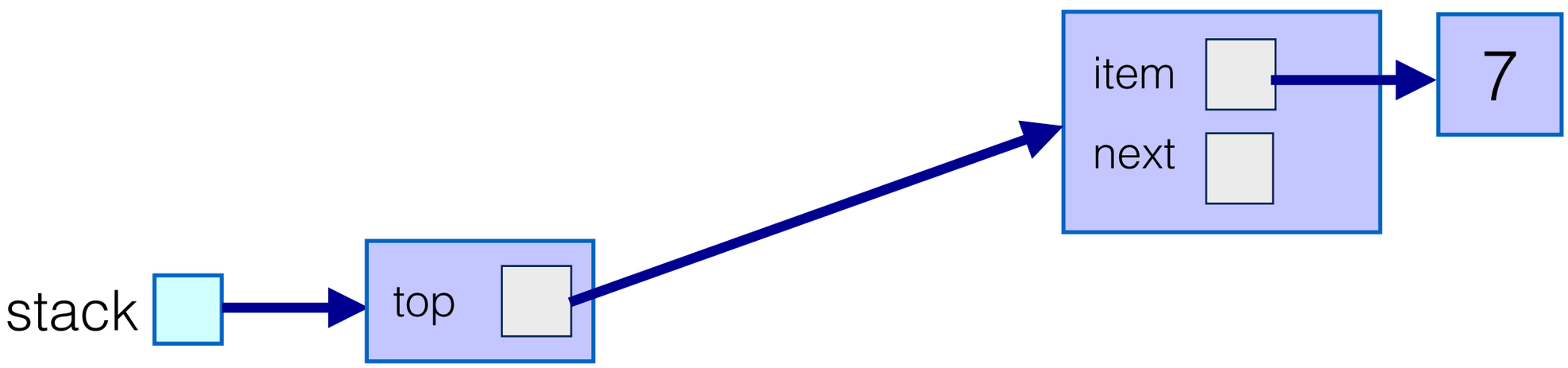

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    assert not self.is_empty(), "Stack is empty"
    item = self.top.item
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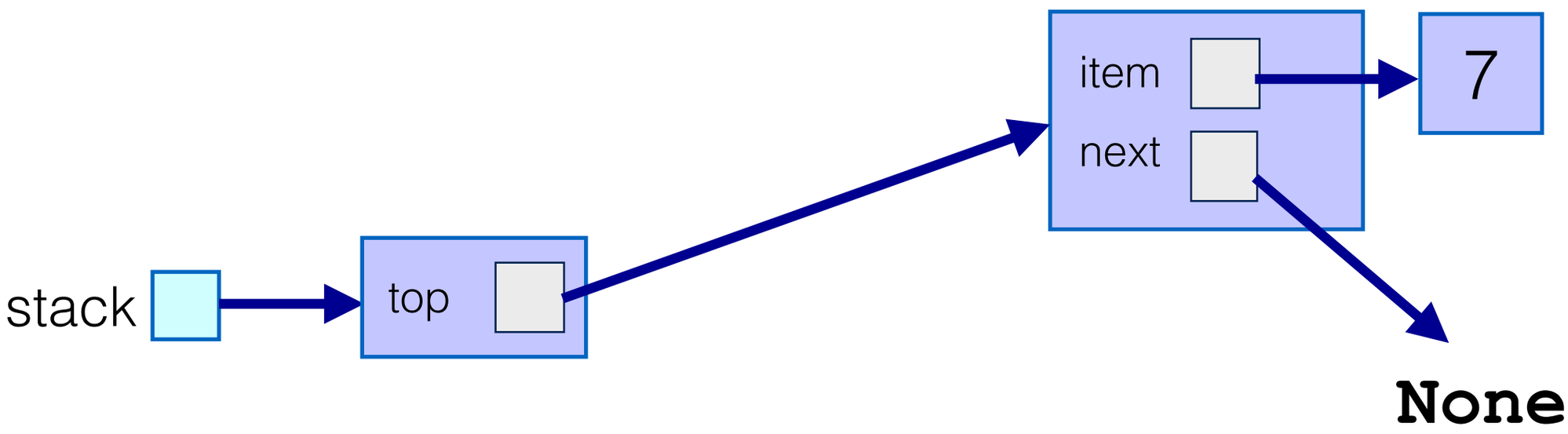

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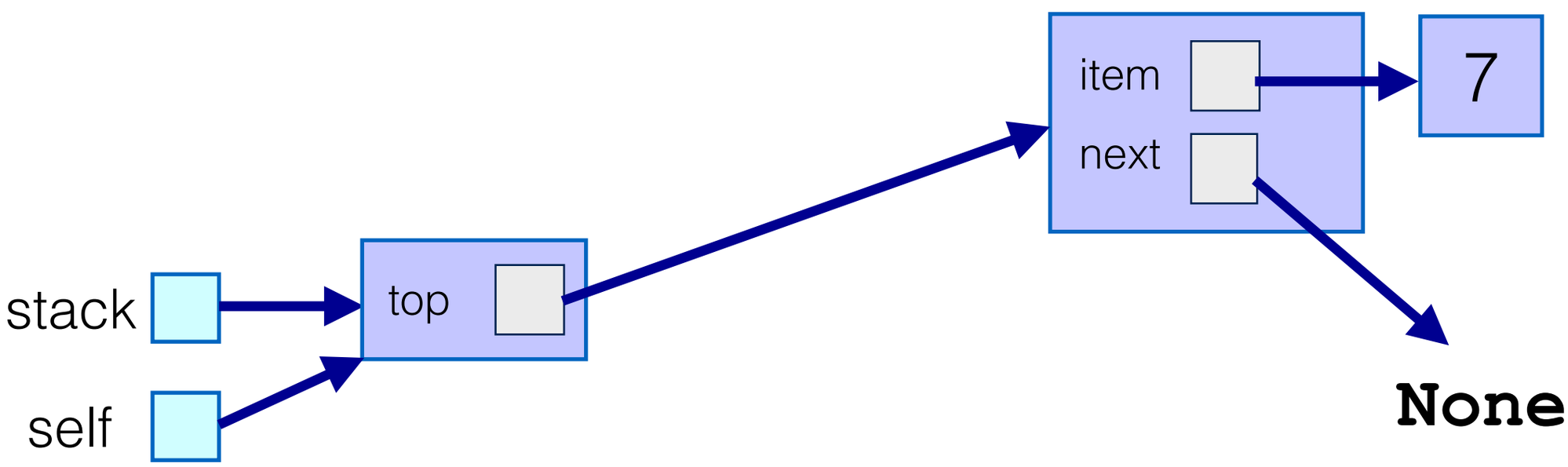

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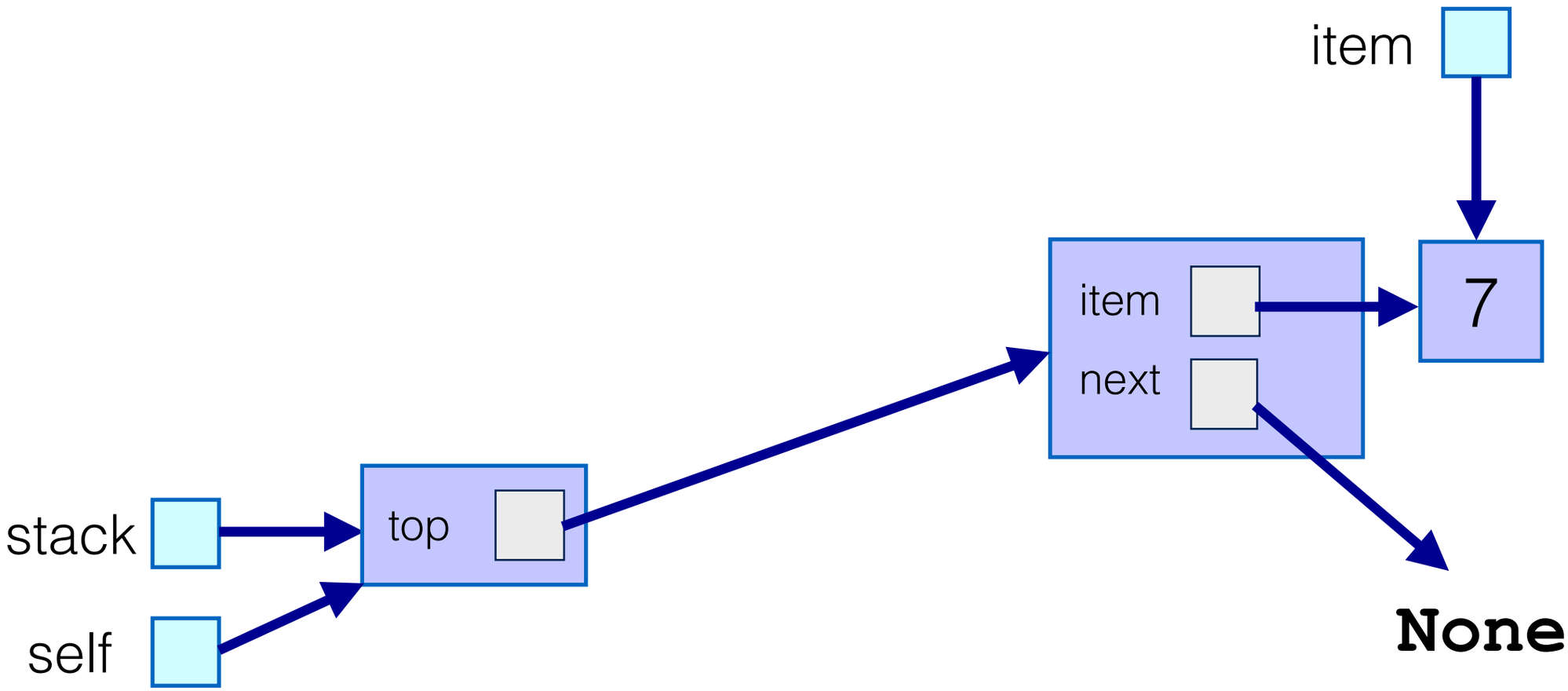

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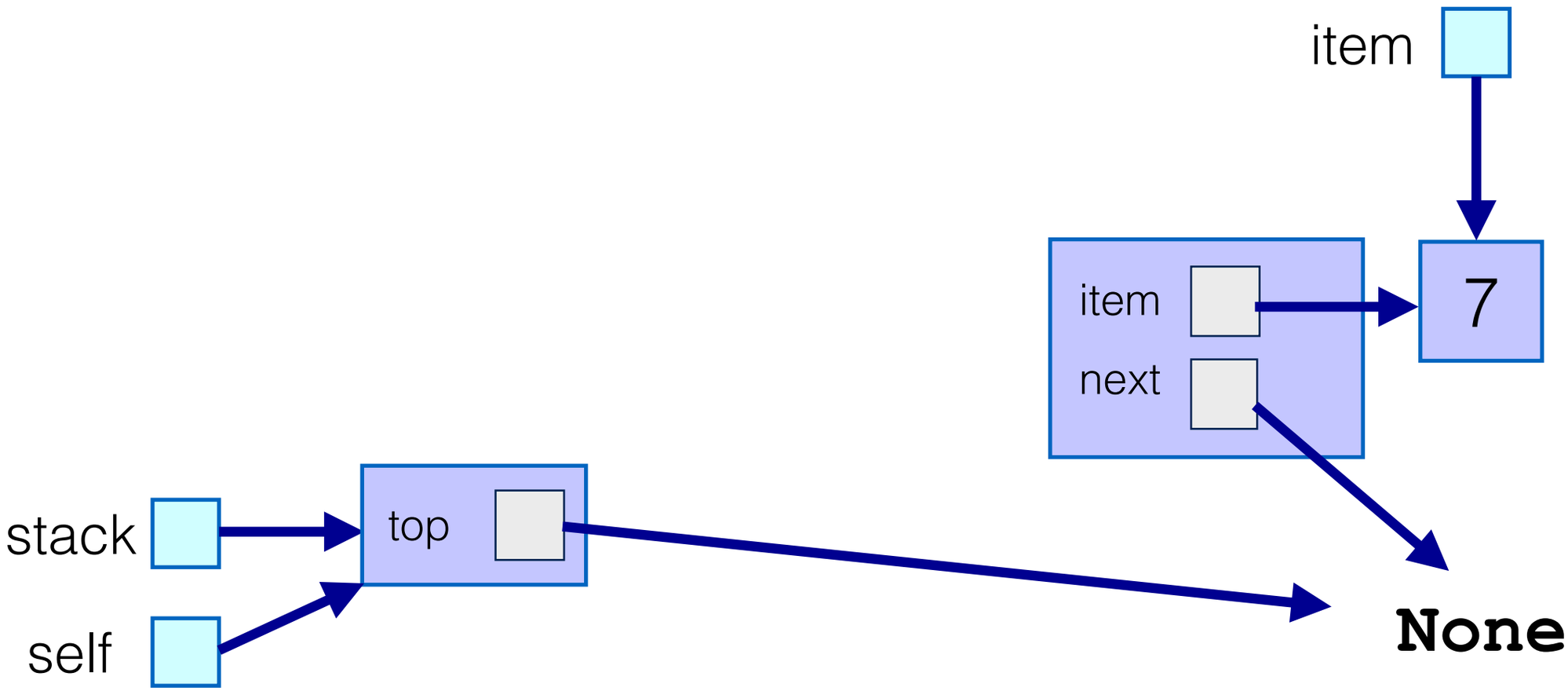

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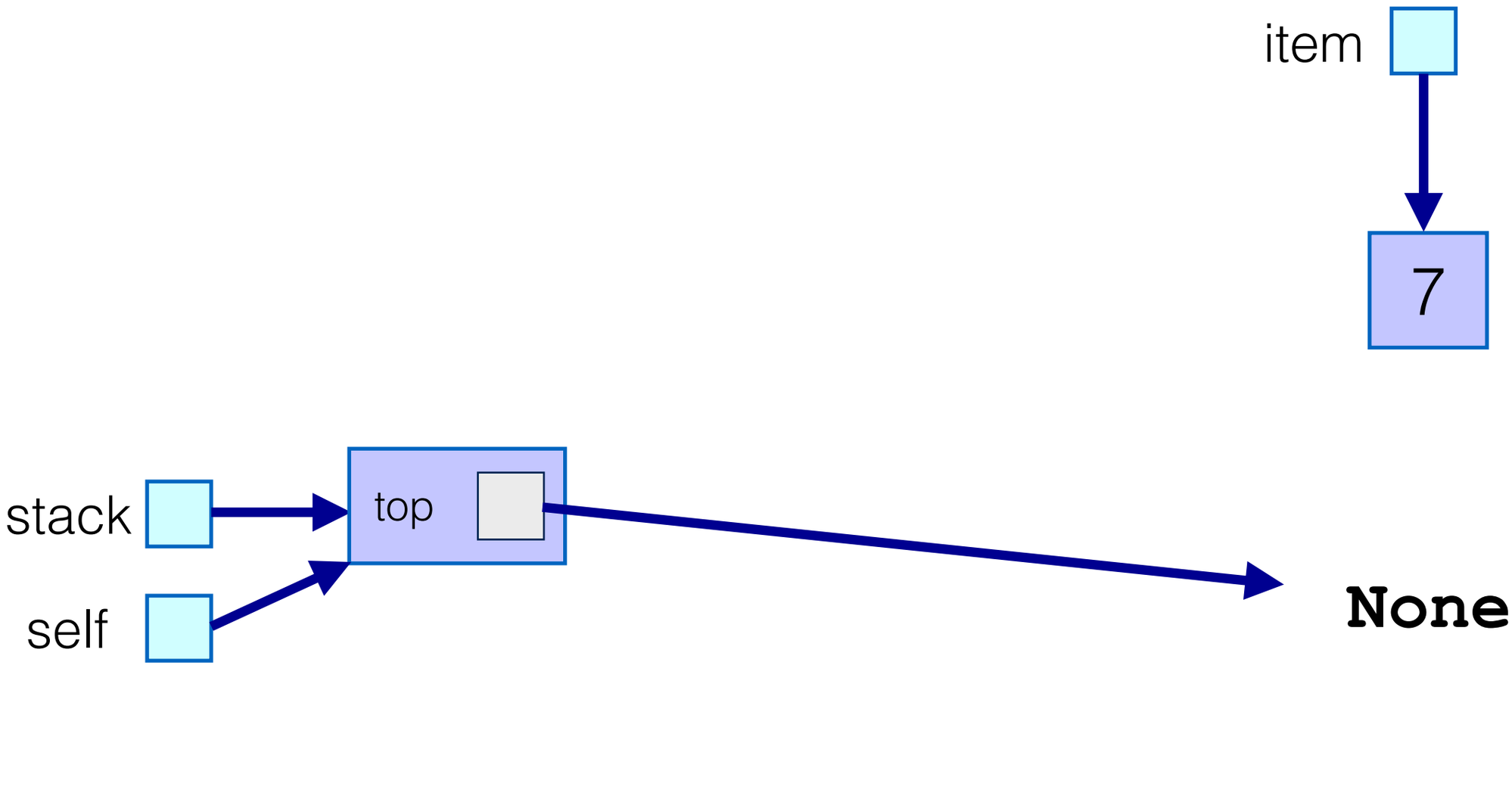

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Summary

- Advantages and disadvantages of linked data structures

- Stacks implemented with linked data structures