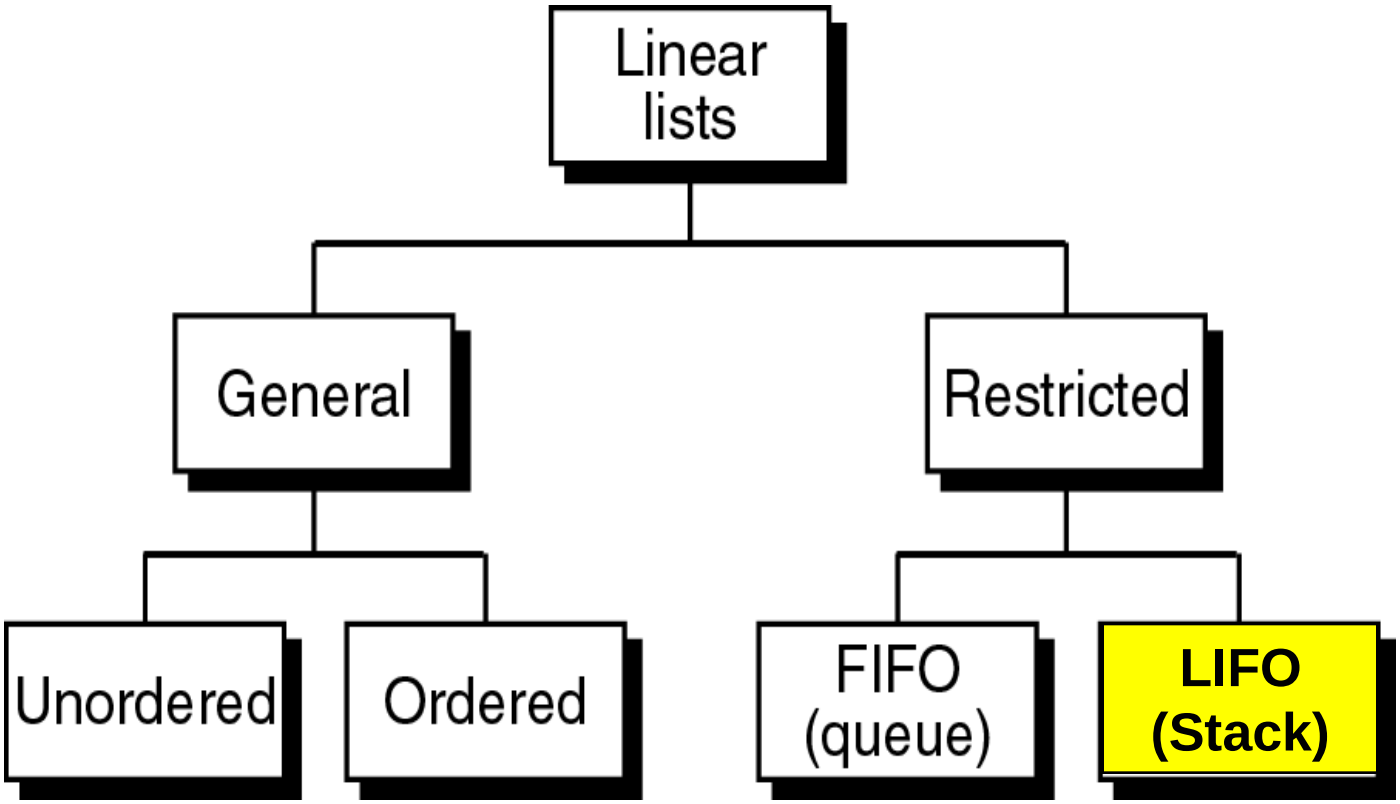
Chapter 3 - STACK

- Definition of Stack
- Specifications for Stack
- Implementations of Stack
- Linked Stack
- Contiguous Stack
- Applications of Stack

Linear List Concepts



Stack ADT

DEFINITION: A Stack of elements of type T is a finite sequence of elements of T, in which all insertions and deletions are restricted to one end, called the top.

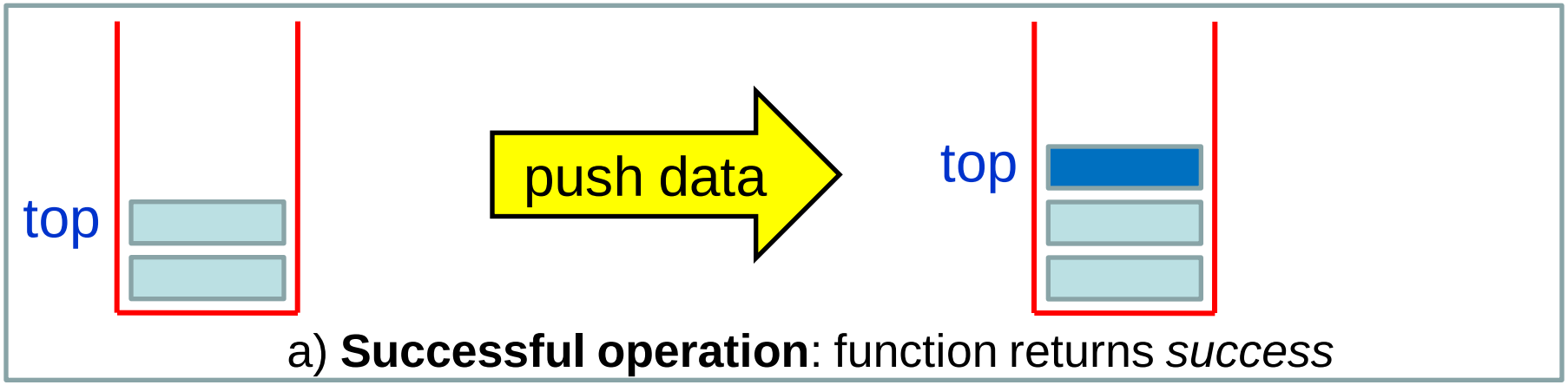
Stack is a Last In - First Out (LIFO) data structure.

Basic operations:

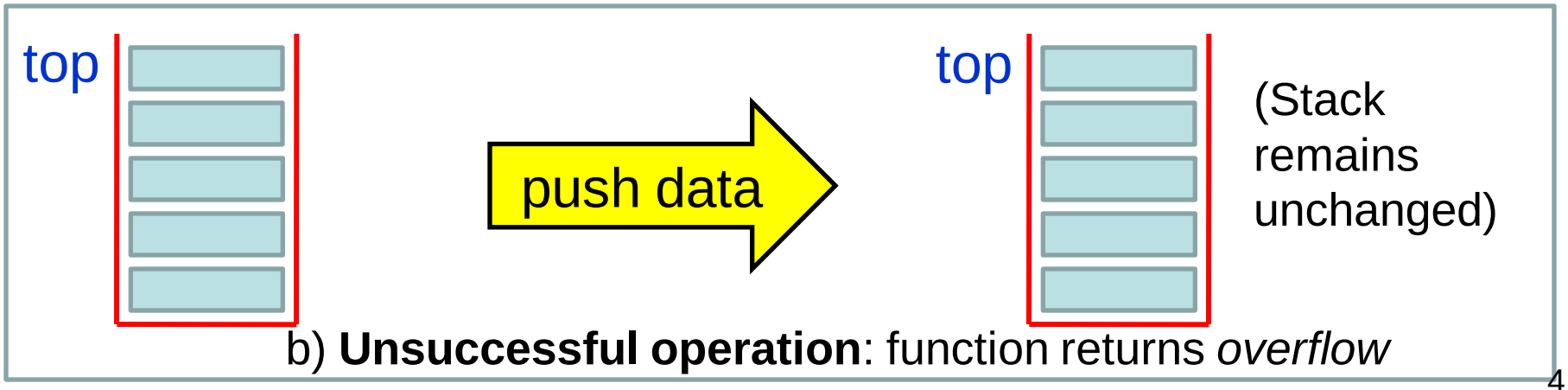
- *Construct* a stack, leaving it empty.
- *Push* an element.
- *Pop* an element.
- *Top* an element.

Basic operation of Stack (Push)

Before **After**



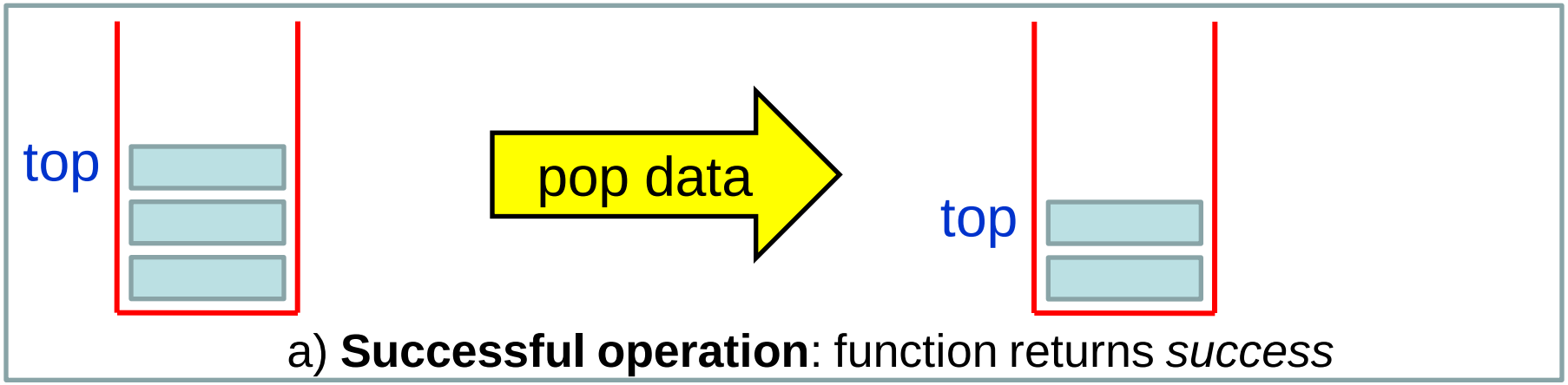
a) **Successful operation**: function returns *success*



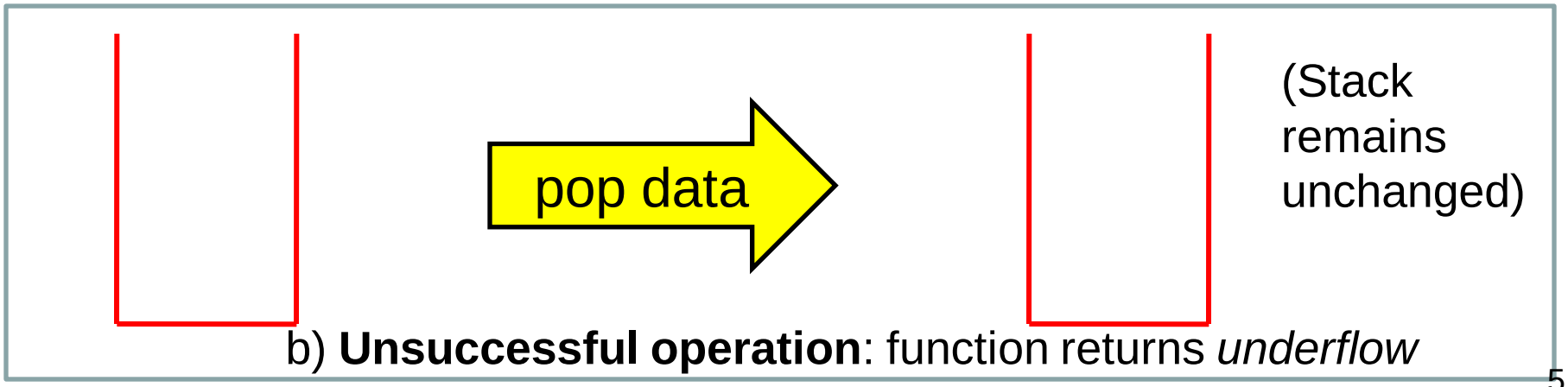
b) **Unsuccessful operation**: function returns *overflow*

Basic operation of Stack (Pop)

Before **After**

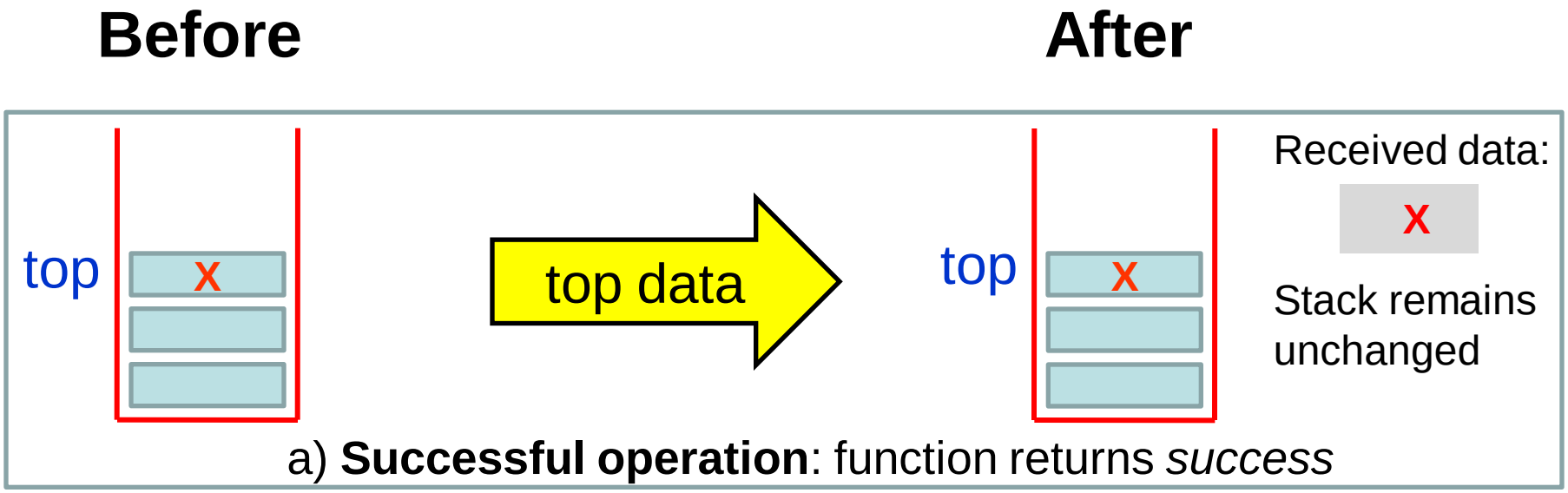


a) **Successful operation**: function returns *success*



b) **Unsuccessful operation**: function returns *underflow*

Basic operation of Stack (Top)



Stack ADT (cont.)

Extended operations:

- Determine whether the stack is *empty* or not.
- Determine whether the stack is *full* or not.
- Find the *size* of the stack.
- *Clear* the stack to make it empty.
- Determine the total number of elements that have ever been placed in the stack.
- Determine the average number of elements processed through the stack in a given period.
- …

Specifications for Stack ADT

<void> **Create**()

<ErrorCode> **Push** (val DataIn <DataType>)

<ErrorCode> **Pop** ()

<ErrorCode> **Top** (ref DataOut <DataType>)

<boolean> **isEmpty** ()

<boolean> **isFull** ()

<integer> **Size** () // the current number of elements in the stack.

Variants of similar methods:

ErrorCode **Pop** (ref DataOut <DataType>)

…

Built a Stack ADT

Stack may be fully inhirited from a List ADT, inside its operations calling List's operations.

Ex.:

```
<ErrorCode> Push (val DataIn <DataType>)
// Call List::InsertHead(DataIn)
      or
// Call List::Insert(DataIn, 0) // 0: insert to the 1st position
end Push
```

```
<ErrorCode> Pop ()
// Call List::RemoveHead()
end Pop
```

Other operations of Stack are similar …

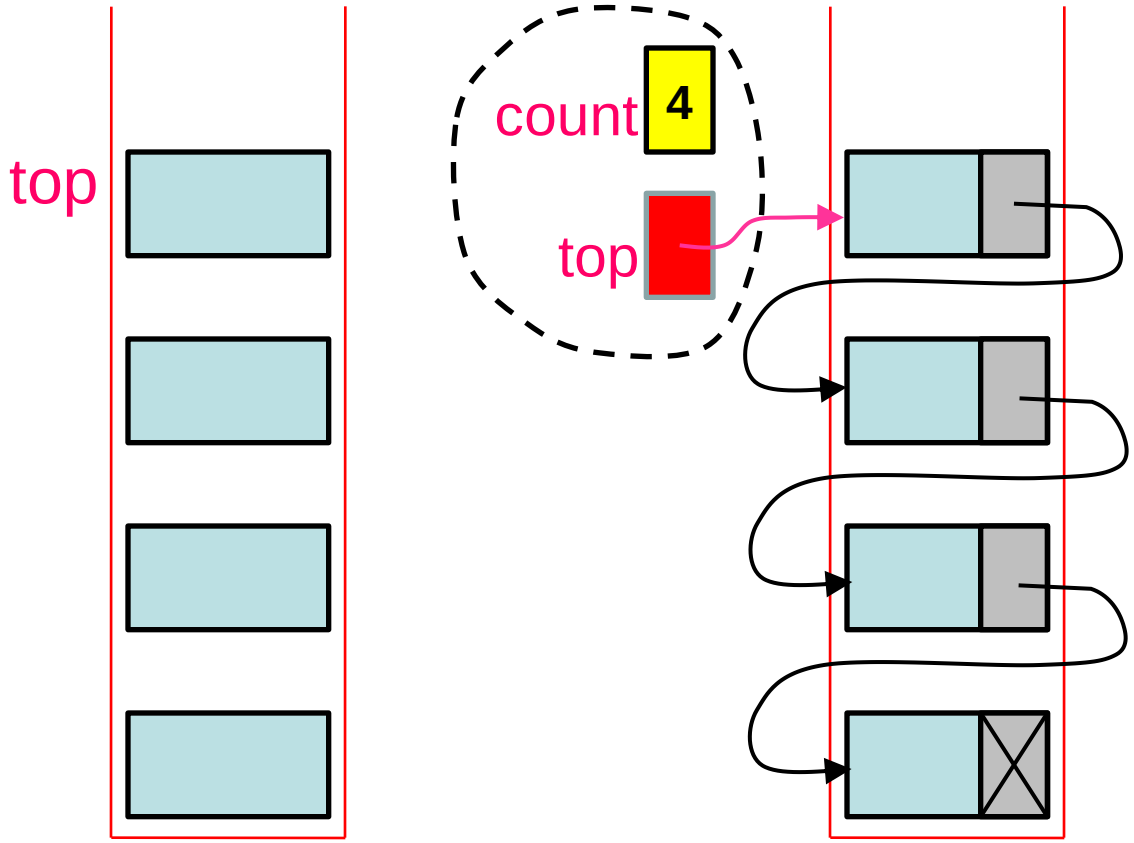
Built a List ADT from Stack ADT

If the Stack ADT has been built first, List ADT may be inhirited from the Stack. Some of its operations call Stack's operations; the others will be added.

Implementations of Stack

- Contiguous Implementation: use an array.
  (May be Automatically or Dynamically Allocated Array)
- Linked Implementation: linked stack.

Linked Stack



a) Conceptual

b) Physical

```
Node
   Data <DataType>
   link <pointer>
end Node
```

```
Stack
   top <pointer>
   count <integer>
end Stack
```

Create Linked Stack

<void> **Create** ()

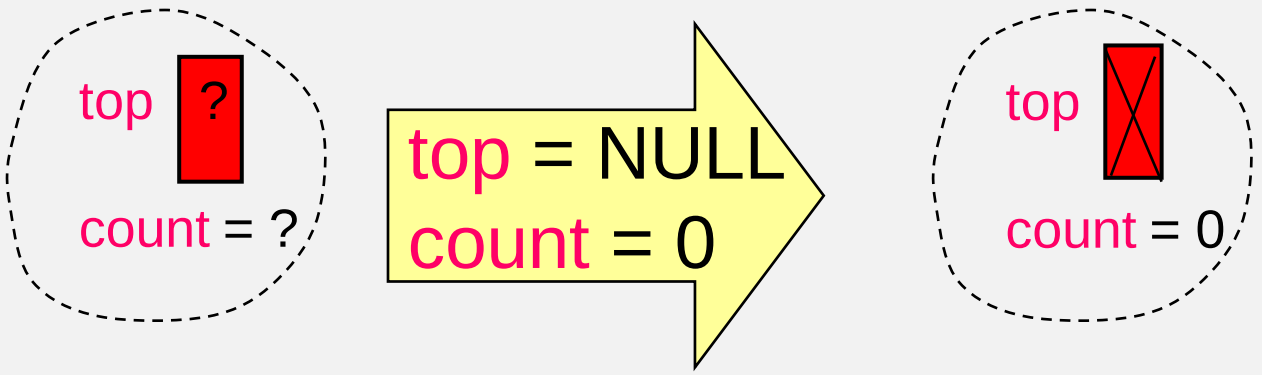
Creates an empty linked stack.

Pre none

Post An empty linked stack has been created.

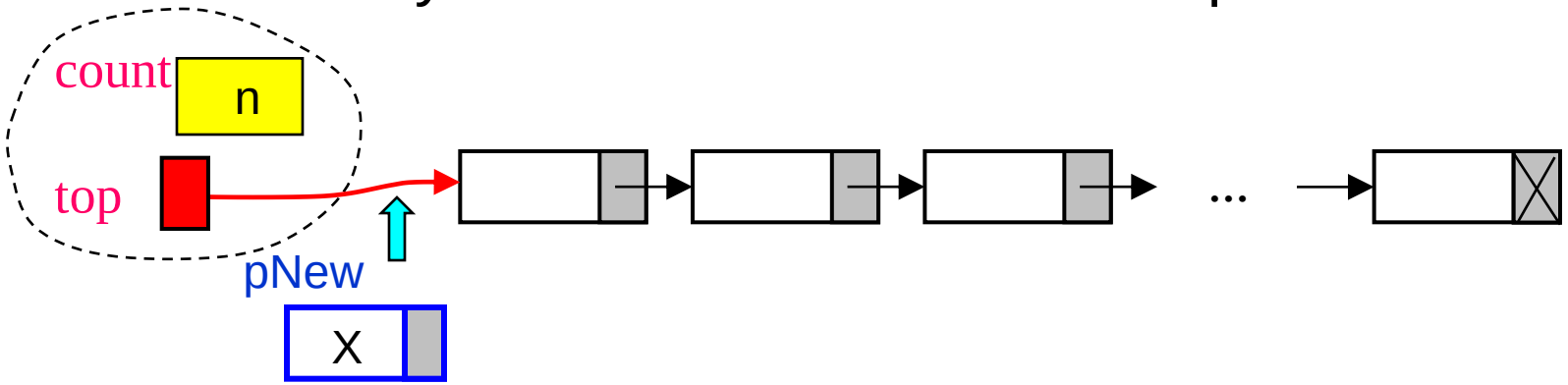
1. top = NULL
2. count = 0
3. return

end Create



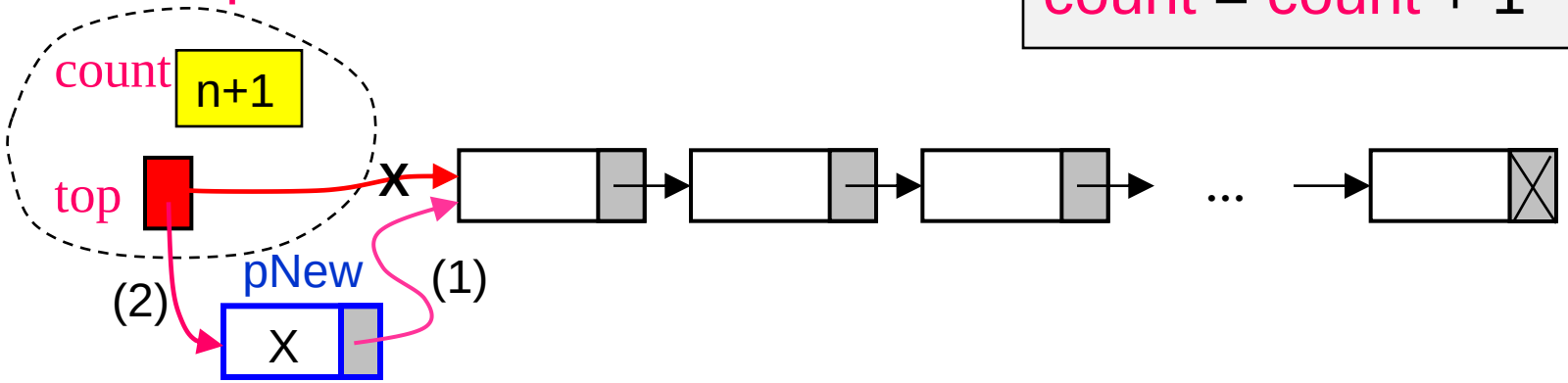
Push data into a Linked Stack

1. Allocate memory for the new node and set up data.



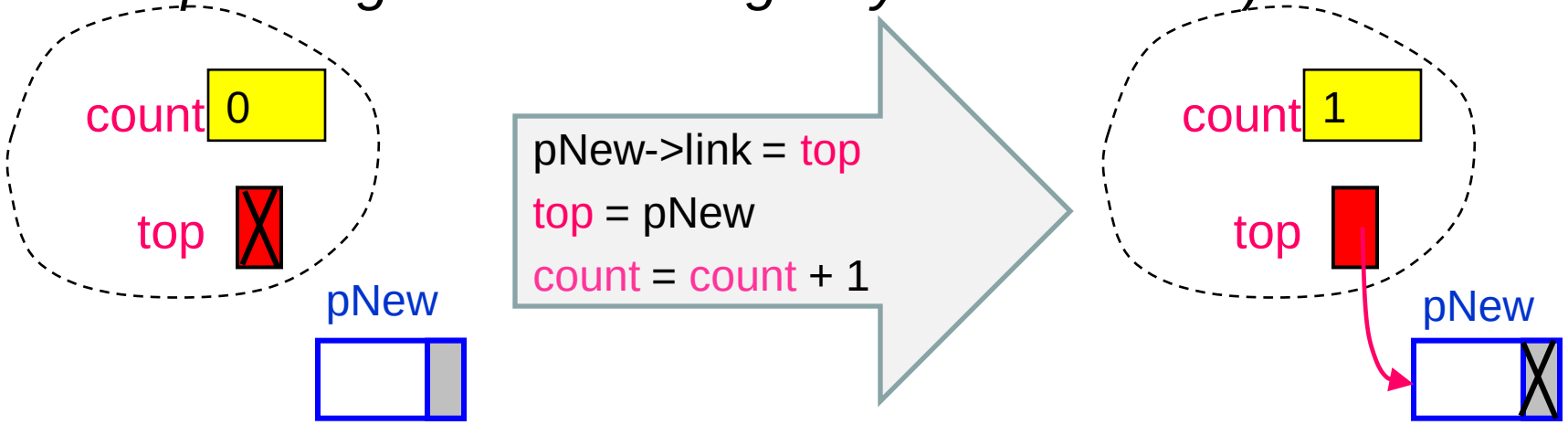
2. Update pointers and count:
   - Point the new node to the top node.
   - Point top to the new node.

pNew->link = top (1)
top = pNew (2)
count = count + 1



Push data into a Linked Stack (cont.)

- Push is successful when allocation memory for the new node is successful.
- There is no difference between push data into a stack having elements and push data into an empty stack (*top having NULL value is assigned to pNew->link: that's corresponding to a list having only one element*).



Push Algorithm (cont.)

<ErrorCode> **Push** (val DataIn <DataType>)

Pushes new data into the stack.

Pre DataIn contains data to be pushed.

Post If stack is not full, DataIn has been pushed in; otherwise, stack remains unchanged.

Return *success* or *overflow*.

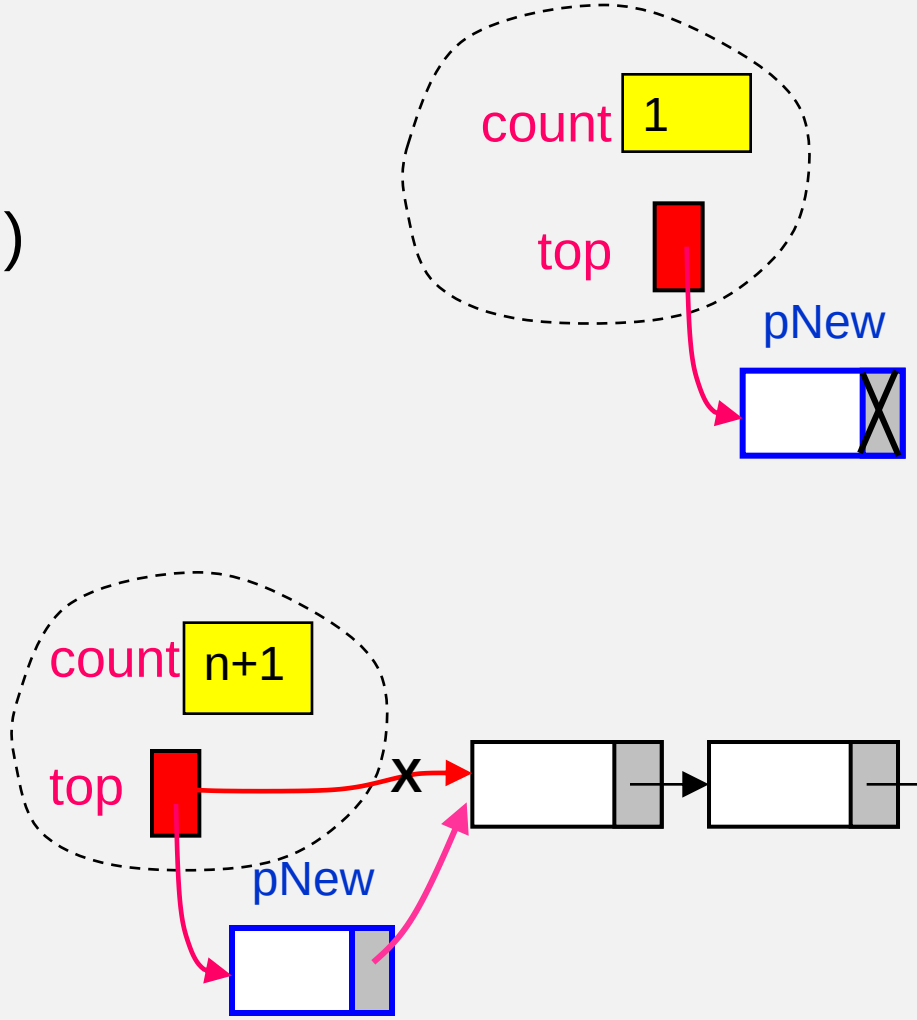
Push Algorithm (cont.)

<ErrorCode> **Push** (val DataIn <DataType>)

// For Linked Stack

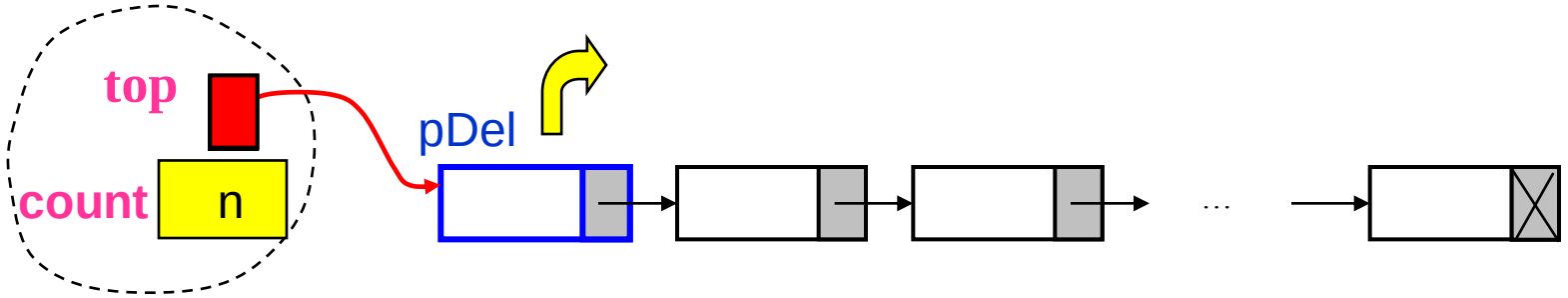
1. Allocate pNew
2. If (allocation was successful)
    1. pNew->data = DataIn
    2. pNew->link = top
    3. top = pNew
    4. count = count + 1
    5. return *success*
3. Else
    1. return *overflow*

end Push



Pop Linked Stack

1. pDel holds the element on the top of the stack.

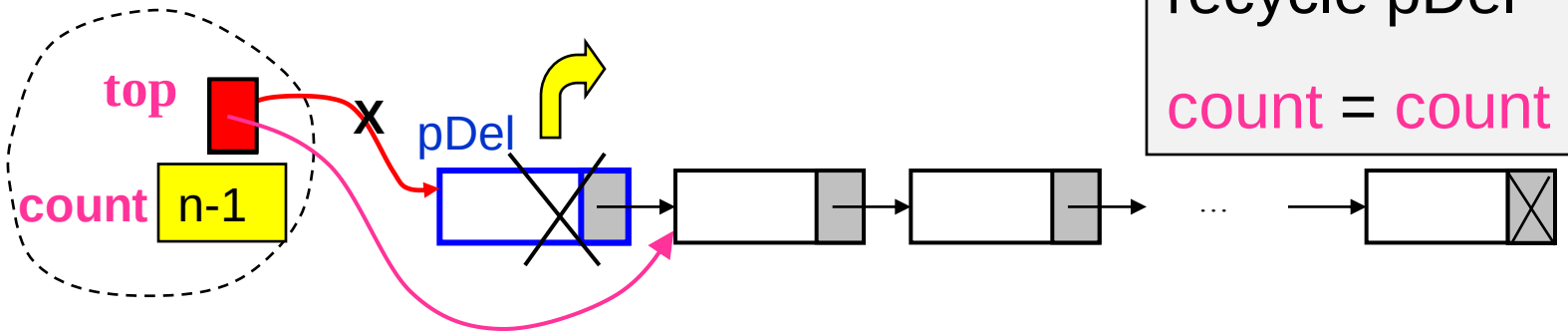


2. top points to the next element.

top = pDel->link

recycle pDel

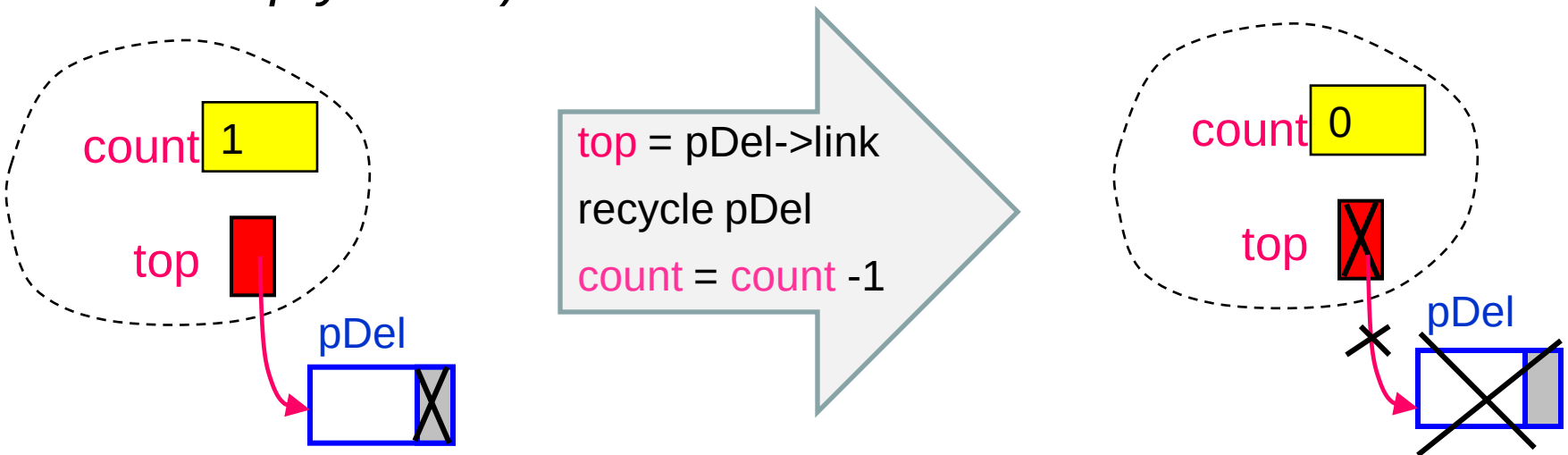
count = count -1



3. Recycle pDel. Decrease count by 1.

Pop Linked Stack (cont.)

- Pop is successful when the stack is not empty.
- There is no difference between pop an element from a stack having elements and pop the only-remained element in the stack (*pDel->link having NULL value is assigned to top: that's corresponding to an empty stack*).



Pop Algorithm

<ErrorCode> Pop()

Pops an element from the top of the stack

Pre none

Post If the stack is not empty, the element on the top has been removed; otherwise, the stack remains unchanged.

Return *success* or *underflow*.

Pop Algorithm (cont.)

<ErrorCode> **Pop**()

Pops an element from the top of the stack

// For Linked Stack

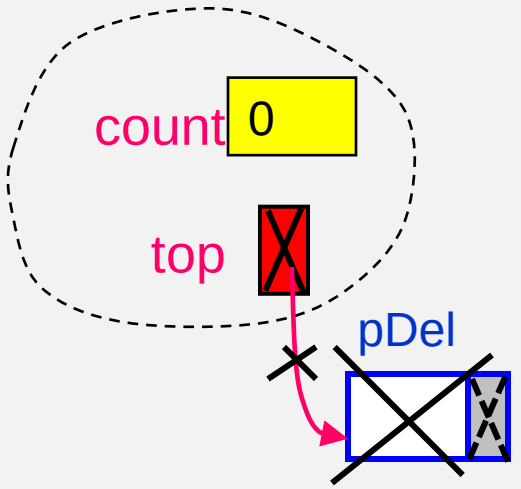
1. If (count > 0)

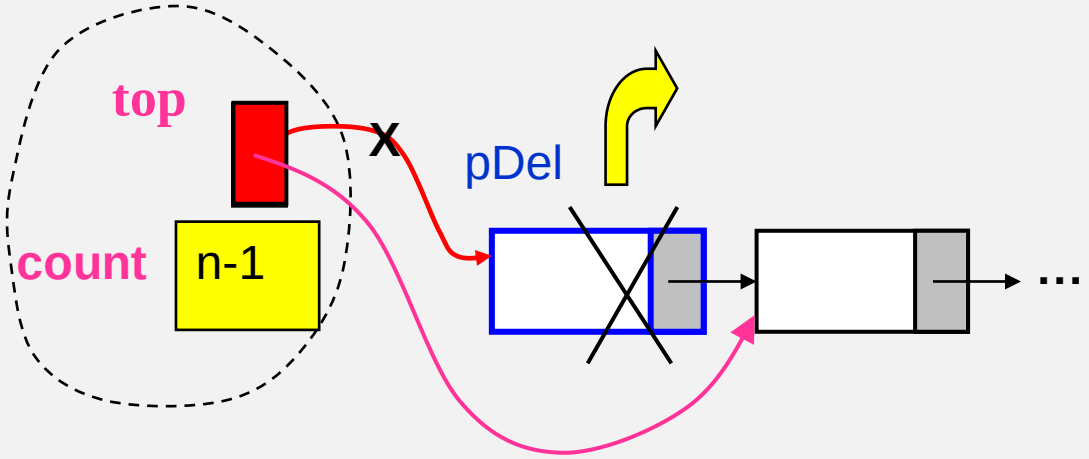
1. pDel = top
2. top = pDel->link
3. recycle pDel
4. count = count - 1
5. return *success*

2. else

1. return *underflow*

3. end Pop





Top Algorithm (cont.)

<ErrorCode> **Top** (ref DataOut <DataType>)

Retrieves data on the top of the stack without changing the stack.

Pre none.

Post if the stack is not empty, DataOut receives data on its top.
The stack remains unchanged.

Return *success* or *underflow.*

// For Linked Stack

1. If (count > 0)
    1. DataOut = top->data
    2. Return *success*
2. Else
    1. Return *underflow*
3. End Top

isEmpty Linked Stack

<boolean> **isEmpty**()

Determines if the stack is empty.

Pre none

Post return stack status

Return TRUE if the stack is empty, FALSE otherwise

1. if (count = 0)

    1. Return TRUE

2. else

    1. Return FALSE

end isEmpty

isFull Linked Stack

<boolean> **isFull**()

Determines if the stack is full.

Pre none

Post return stack status

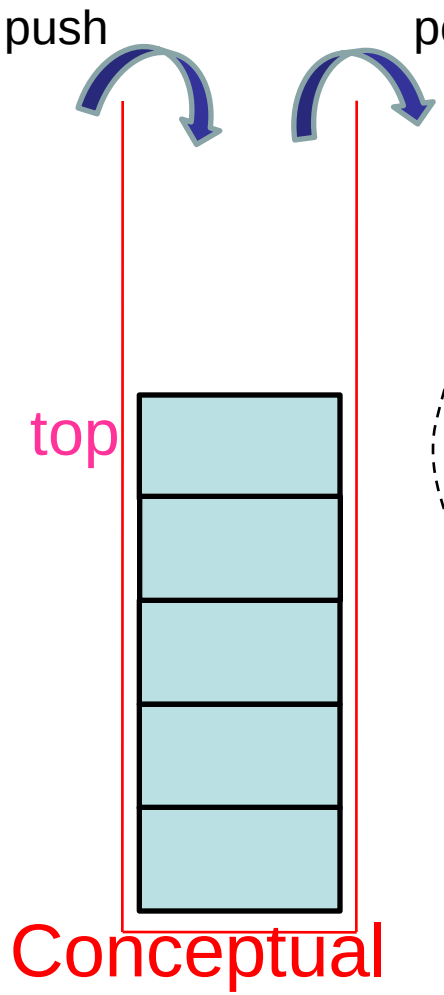
Return TRUE if the stack is full, FALSE otherwise

// For Linked Stack

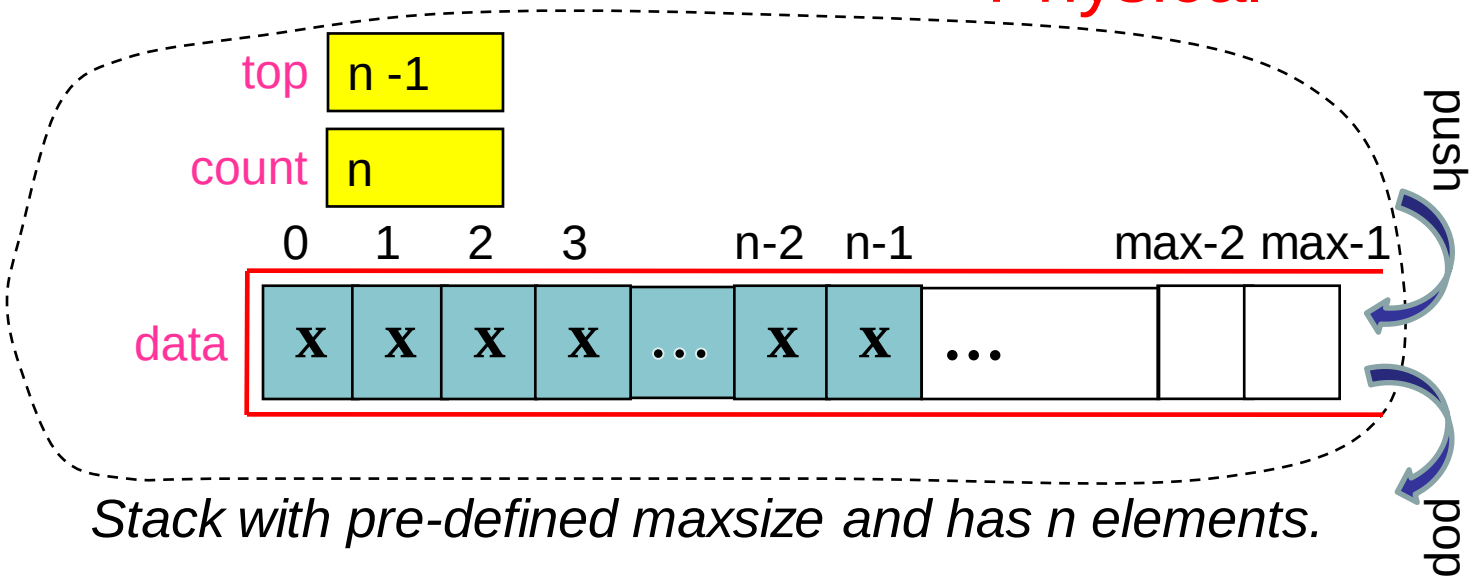
1. Allocate pNew // pNew is NULL if unsuccessful.
2. **if** (pNew is not NULL)
    1. recycle pNew
    2. return TRUE
3. **else**
    1. return FALSE

end isFull

Contiguous Implementation of Stack



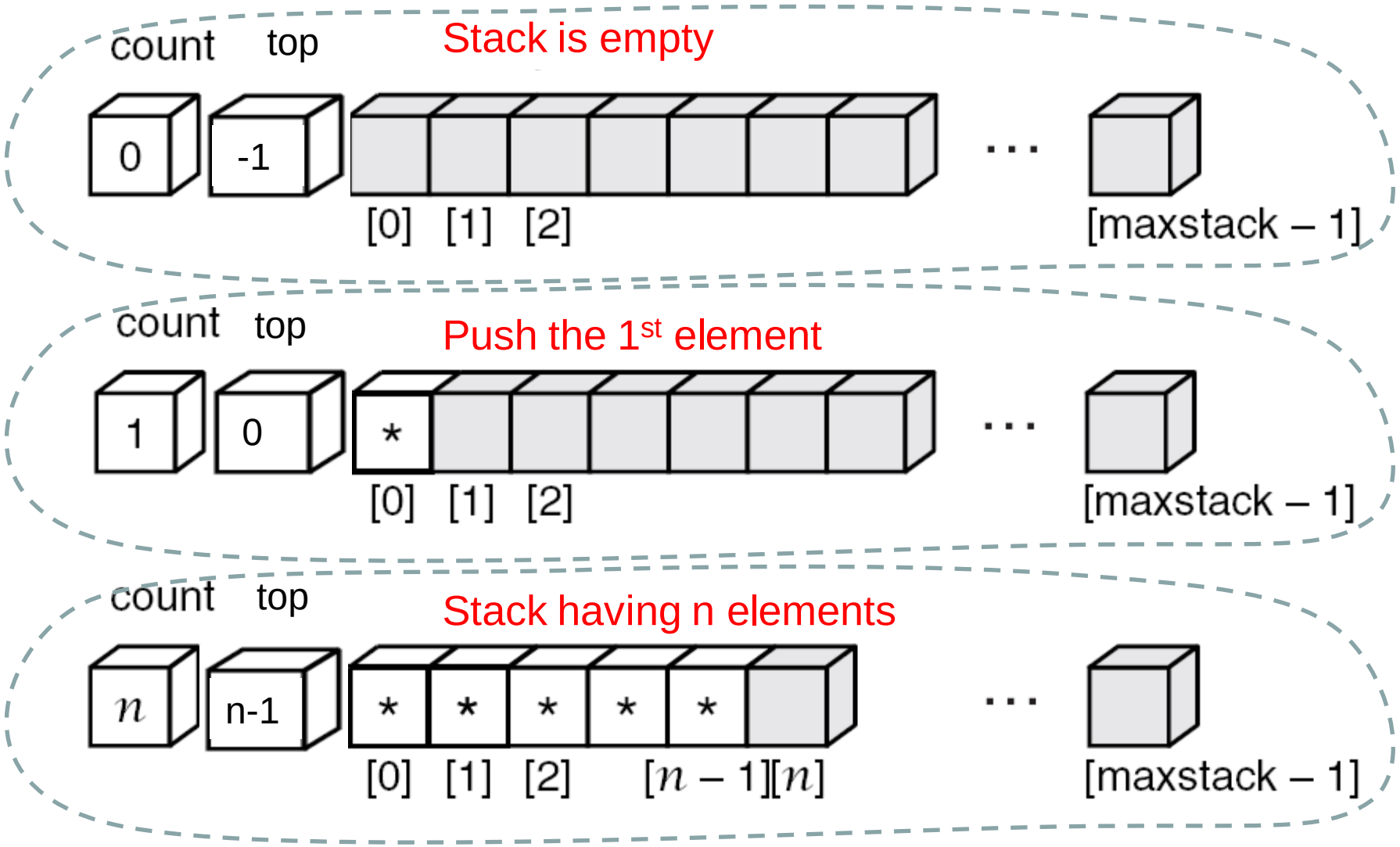
(Automatically Allocated Array)



Stack with pre-defined maxsize and has n elements.

```
Stack
    top <integer>
    count <integer>
    data <array of <DataType>>
End Stack
```

Contiguous Implementation of Stack (cont.)



Create Stack

<void> **Create**()

// Specifications here are similar to specifications for Linked Stack

1. count = 0
2. top = -1

end Create

Push Stack

<ErrorCode> **Push**(val DataIn <DataType>)

// Specifications here are similar to specifications for Linked Stack

1. **if** (count = maxsize)
    1. return *overflow*
2. **else**
    1. top = top + 1
    2. data[top] = DataIn
    3. count = count + 1
    4. return *success*

end Push

Pop Stack

<ErrorCode> **Pop**()

// Specifications here are similar to specifications for Linked Stack

1. **if** (stack is empty)
    1. return *underflow*
2. **else**
    1. top = top – 1
    2. count = count - 1
    3. return *success*

end Pop

Top Stack

<ErrorCode> **Top**(ref DataOut <DataType>)

// Specifications here are similar to specifications for Linked Stack

1. **if** (count = 0)
    1. return *underflow*
2. **else**
    1. DataOut = data[top]
    2. return *success*

end Top

Stack status

```
<boolean> isEmpty()
1. if (count = 0)
    1. return TRUE
2. Else
    1. return FALSE
end isEmpty
```

```
<boolean> isFull()
1.  if (count = maxsize)
    1. return TRUE
2.  Else
    1. return FALSE
end isFull
```

```
<integer> size()
1.  return count
end size
```