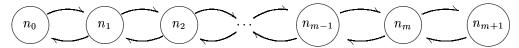
## Implementation of a deque with a doubly linked list with dummy nodes

## Variables

size: integer

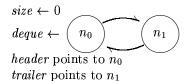
deque: doubly linked list with dummy nodes at the front and the rear; each node, apart from the dummy nodes  $n_0$  and  $n_{m+1}$ , contains an element of the deque



header: pointer to node trailer: pointer to node

*invariant*: the nodes  $n_1, \ldots, n_m$  of deque contain the elements of the deque listed from front to rear. size is the size of the deque. header points to  $n_0$  and trailer points to  $n_{m+1}$ .

## Initialization



## Algorithms

size()

output: size of deque

return size

isEmpty()

*output*: deque is empty?

return (size = 0)

first()

precondition: deque is nonempty
output: element at the front of deque

return element of second node of deque

last()

precondition: deque is nonempty

output: element at the rear of deque

return element of one but last node of deque

 $insertFirst(\mathit{element})$ 

postcondition: element has been added to the front of deque

input: element to be added to deque

add new node with element element in between header and the second node of deque

 $size \leftarrow size + 1$ 

insertLast(element)

postcondition: element has been added at the rear of deque

input: element to be added to deque

add new node with element element in between trailer and the one but last node of deque

 $size \leftarrow size + 1$ 

removeFirst()

precondition: deque is nonempty

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\begin{array}{c} \textit{postcondition:} \text{ first element has been removed from deque} \\ \textit{output:} \text{ first element of deque} \\ \textit{temp} \leftarrow \text{ element of second node of } \textit{deque} \\ \textit{remove second node from } \textit{deque} \\ \textit{size} \leftarrow \textit{size} - 1 \\ \textbf{return } \textit{temp} \\ \textbf{removeLast()} \\ \textit{precondition:} \text{ deque is nonempty} \\ \textit{postcondition:} \text{ last element has been removed from deque} \\ \textit{output:} \text{ last element of deque} \\ \textit{temp} \leftarrow \text{ element of one but last node of } \textit{deque} \\ \textit{remove one but last node from } \textit{deque} \\ \textit{size} \leftarrow \textit{size} - 1 \\ \textbf{return } \textit{temp} \\ \end{array}
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