Programmeren (Ectrie)

Lecture 5: Linear data structures

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Halting problem revisited

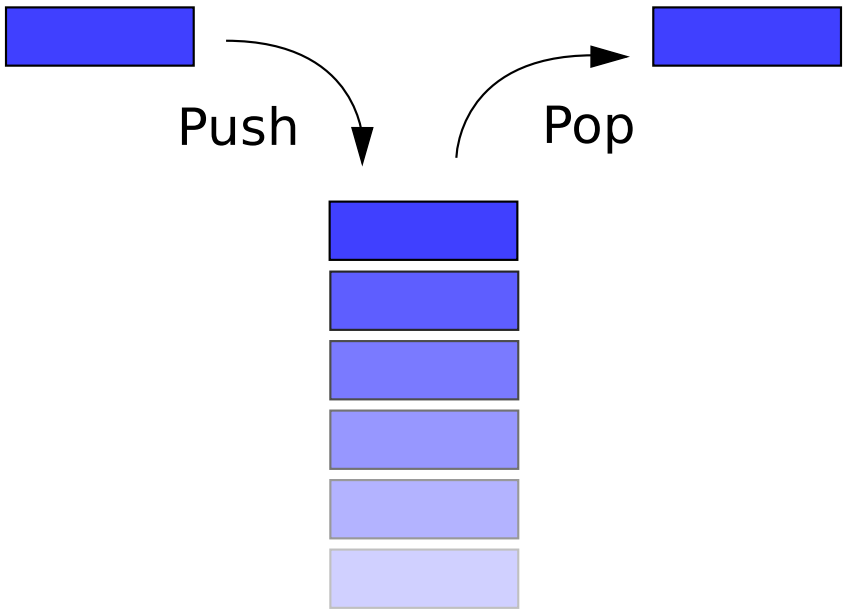
```
H(P)
   If P will halt, then say "YES!"
   If P will not halt, then say "NO!".

K(P)
   If "H(P)" says "YES!", then loop infinitely.
   If "H(P)" says "NO!", then STOP!"

K(K)
   If H(K) says "YES!", then loop infinitely.
   If H(K) says "NO!", then STOP.
```

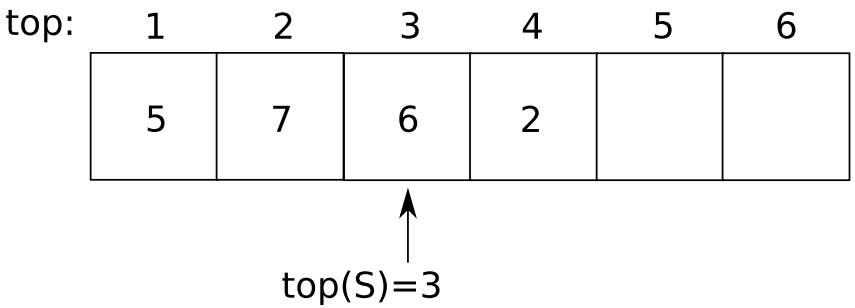
Array

- *Data structures* allow to store a set of elements and guarantee certain complexity for elementary operations (access, insert, delete, search x, search min/max)
- Arrays are the most elementary data structures
- Random access: O(1)
- All other operations: O(n)

Stack

- Last-In First-Out access semantics (LIFO)
- Can be implemented using an array and index of top element



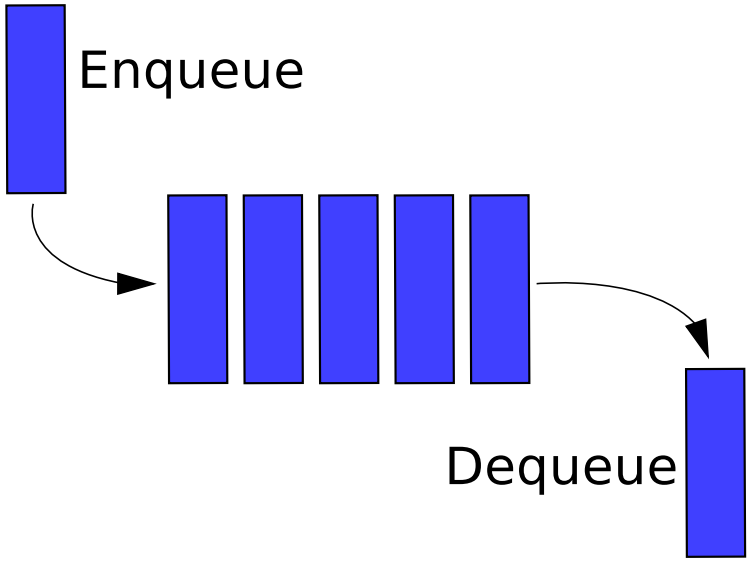


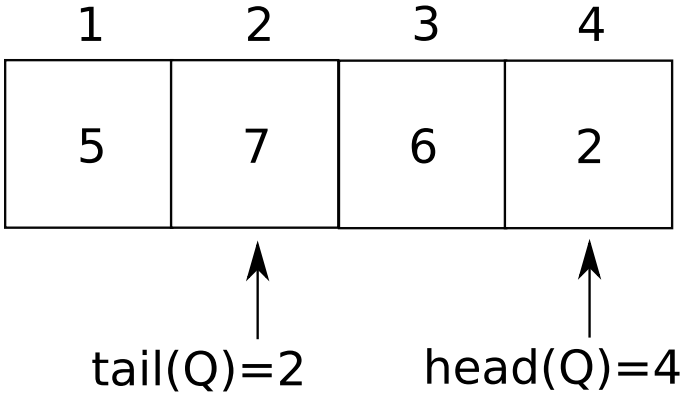
Use of stacks: call stack

- When you make a method call, the new frame of execution (local variables) is pushed to the stack
- When the method exists, the local variables are simply popped from the stack

Queue

- First-In First-Out access semantics (FIFO)
- Can be implemented using an array and indices of first (head) and last (tail) elements
- Empty queue is denoted with head $= 0$, tail $= 1$





4 queues (3, 7, 6, 2), 3 dequeues (delete 3, 7 and 6), and 1 enqueue (5): contents of Q are [2, 5].

Use of queues: simulation with (multiple) queues

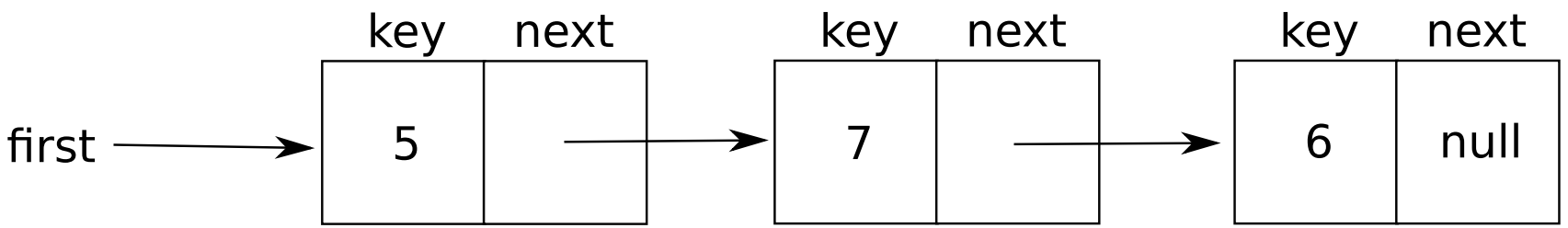
- Many practical problems can be modeled with queues
- E.g. factory arriving material to be processed, process step 1 storage, process step 2 storage, ...

Dynamic data structures

- Until now all the data structures we considered have been static
- When elements are constantly inserted / deleted, static structures are slow (O(n))
- Need for node-based dynamic structures

Linked list

- Linked list is a list where each element has it's own node, that contains the key and a reference to the next node
- Can be used to implement a stack



Pass by reference in Matlab with OO

- OO-extensions and their use in passing by reference

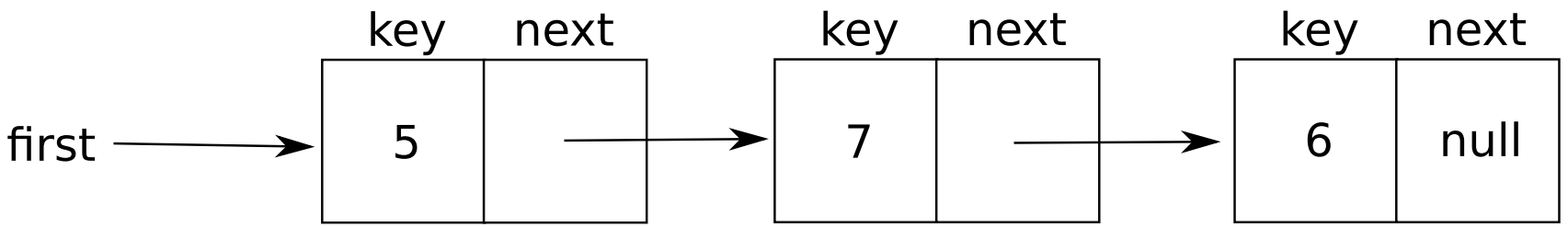
```
classdef node < handle
   properties
      key
      next
   end
end
```

Linked list construction

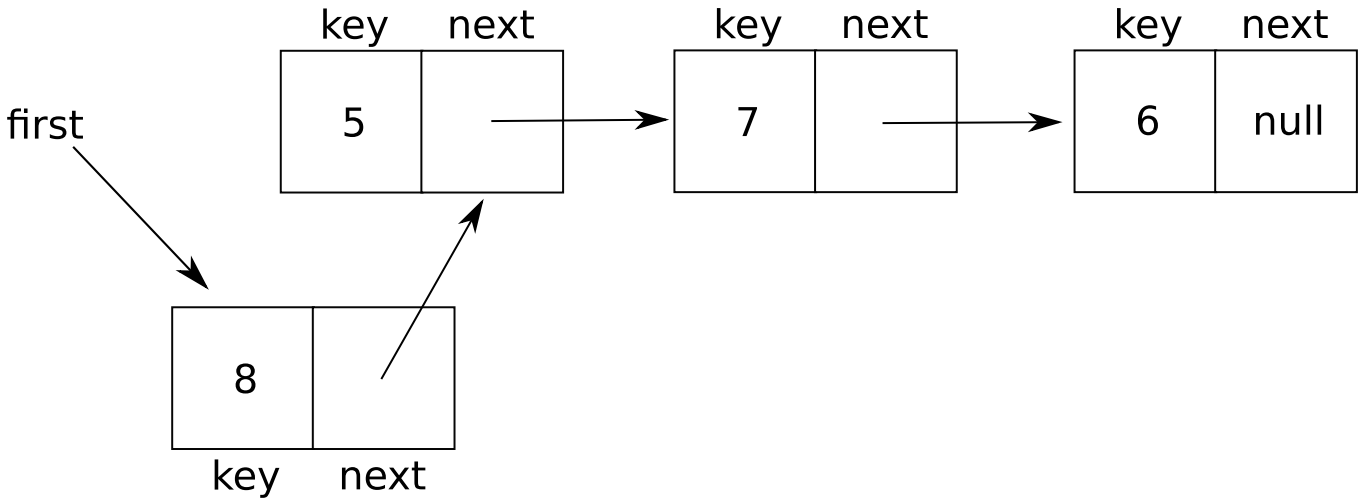
```
classdef linkedlist < handle
   properties
      first
   end
end

function L = initLinkedList(value)
   L = linkedList();
   fNode = node();
   fNode.key = value;
   fNode.next = NaN;
   L.first = fNode;
end
```

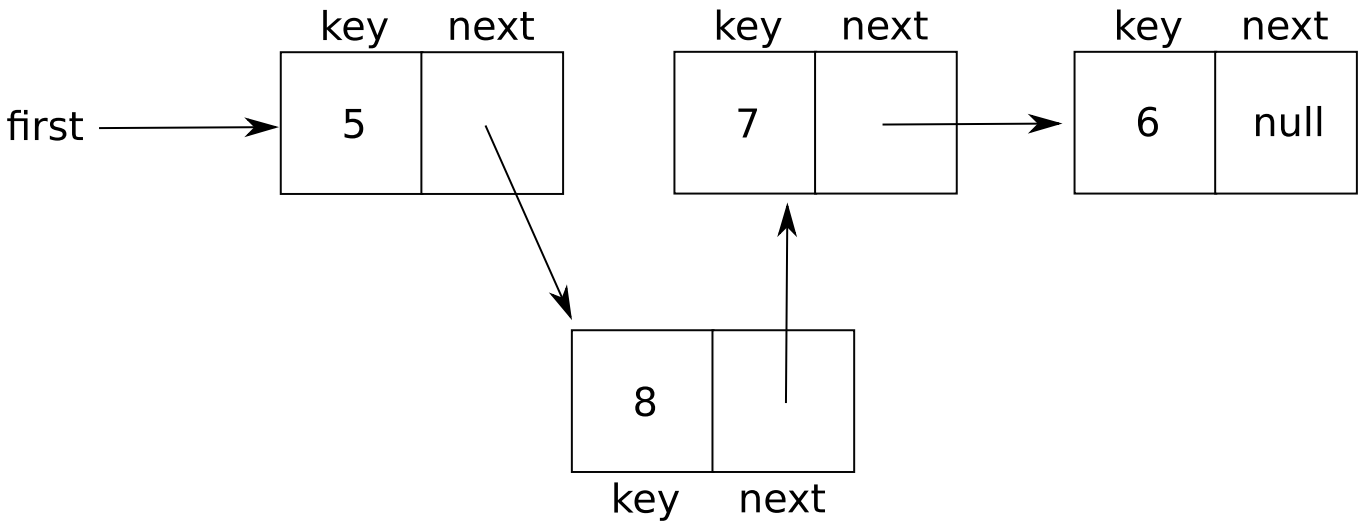
Linked list traversal

```
function node = findKey(L, key)
  curNode = L.first;
  while (curNode != NaN)
    if (curNode.key == key)
      node = curNode;
      break;
    end
    curNode = curNode.next;
  end
end
```

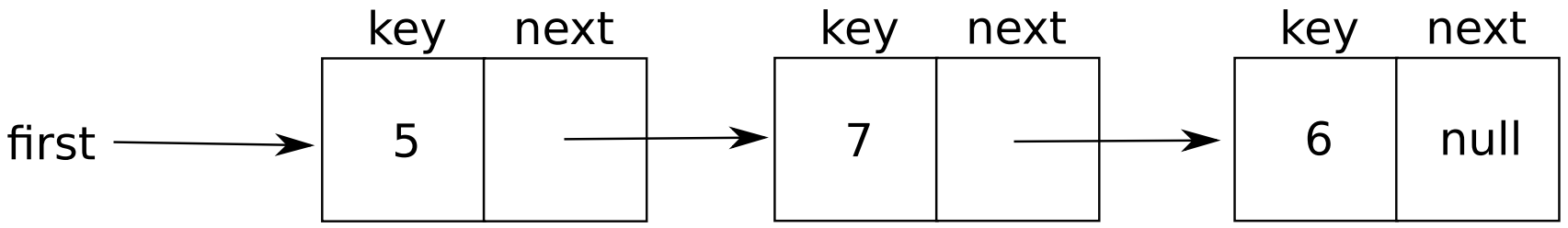


Linked list insert element

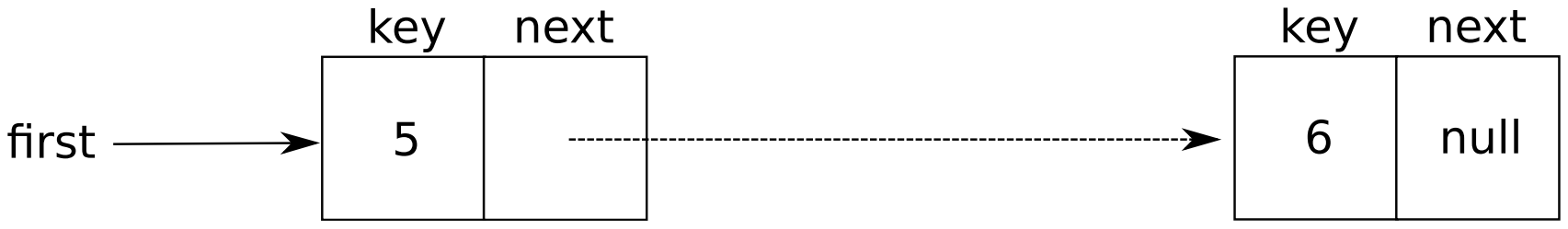




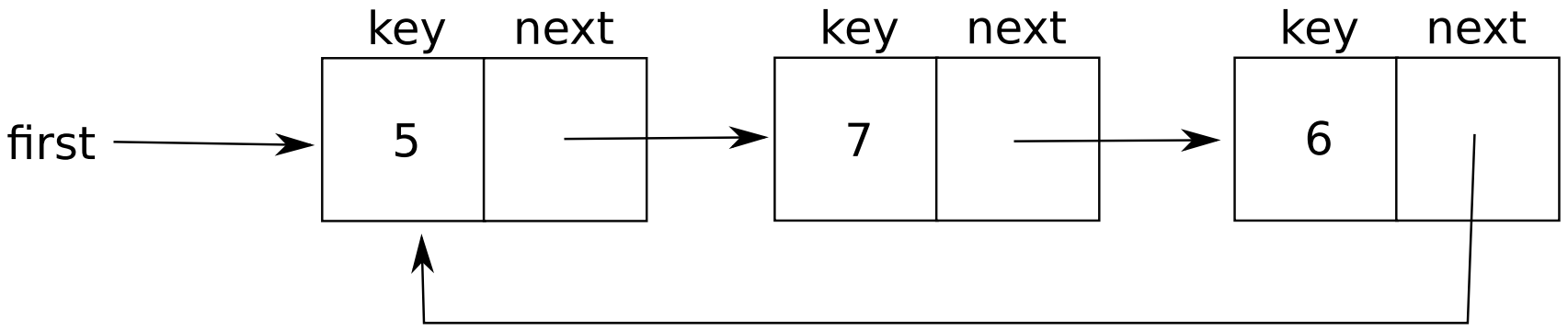
Linked list delete element



deleteNodeAfter(nodeOf5)



Circular linked list



- Uses: round-robin scheduling of processes in multi-tasking environments (e.g. your computer)

Complexity of linked list operations

- Insert/delete element in beginning: O(1)
- Insert/delete element at current iteration location: O(1)
- Random access: O(n)
- Search: O(n)