Maps

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These slides have been extracted, modified and updated from original slides of :
Data Structures and Algorithms in Java, 5th edition. John Wiley& Sons, 2010. ISBN 978-0-470-38326-1.
Data Structures and the Java Collections Framework by William J. Collins, 3rdedition, ISBN 978-0-470-48267-4.
Both books are published by Wiley.

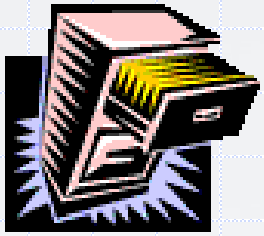
Coverage

- Maps

Maps

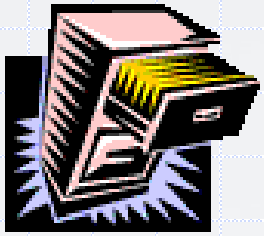
- A map models a searchable collection of key-value entries.
- A map allows us to store elements in a way that attempts to speed up the process of locating them, through the utilization of keys.
- The main operations of a map are searching, inserting, and deleting items.
- Multiple entries with the same key are **not** allowed. In other words, the keys in a map are **unique**.
- Applications:
  - address book
  - student-record database

The Map ADT



- A map supports the following methods:
  - get(k): if a map M has an entry with key k, return its associated value; else, return null
  - put(k, v): insert entry (k, v) into the map M; if key k is not already in M, then return null; else, replace the value associated with k with v and return the old value
  - remove(k): if the map M has an entry with key k, remove it from M and return its associated value; else, return null
  - entrySet(): return an iterable collection containing all the key-value entries in M

The Map ADT



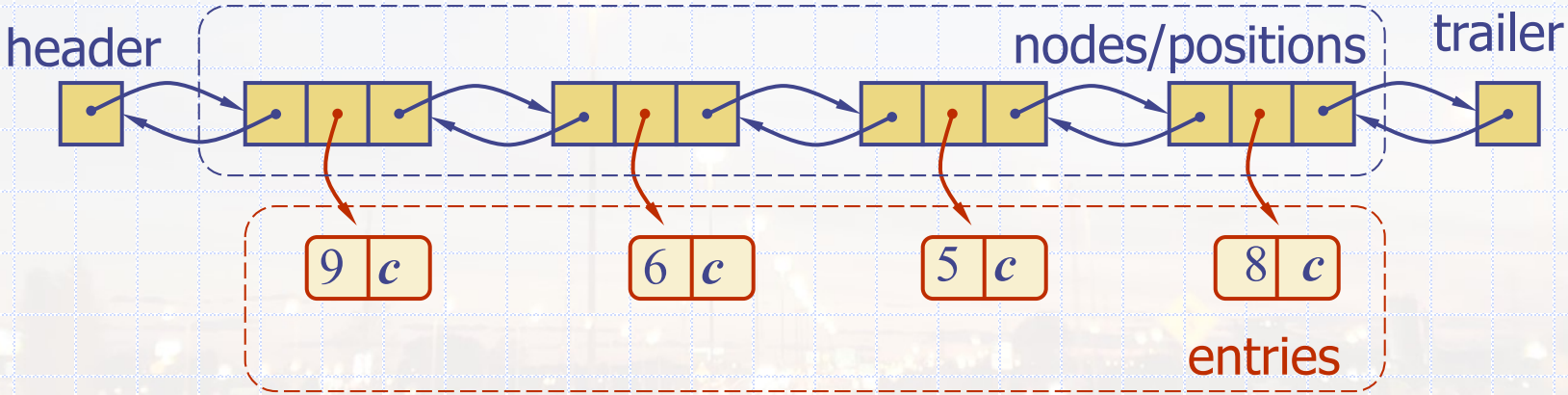
- A map supports the following methods (continues):
  - keySet(): return an iterable collection of all the keys in M
  - values(): return an iterable collection of all the values in M
  - size(): return the number of entries in M
  - isEmpty(): test whether M is empty

Example

Operation	*Output*	*Map*
isEmpty()	**true**	Ø
put(5,*A*)	**null**	(5,*A*)
put(7,*B*)	**null**	(5,*A*),(7,*B*)
put(2,*C*)	**null**	(5,*A*),(7,*B*),(2,*C*)
put(8,*D*)	**null**	(5,*A*),(7,*B*),(2,*C*),(8,*D*)
put(2,*E*)	*C*	(5,*A*),(7,*B*),(2,*E*),(8,*D*)
get(7)	*B*	(5,*A*),(7,*B*),(2,*E*),(8,*D*)
get(4)	**null**	(5,*A*),(7,*B*),(2,*E*),(8,*D*)
get(2)	*E*	(5,*A*),(7,*B*),(2,*E*),(8,*D*)
size()	4	(5,*A*),(7,*B*),(2,*E*),(8,*D*)
remove(5)	*A*	(7,*B*),(2,*E*),(8,*D*)
remove(2)	*E*	(7,*B*),(8,*D*)
get(2)	**null**	(7,*B*),(8,*D*)
isEmpty()	**false**	(7,*B*),(8,*D*)

A Simple List-Based Map

- We can efficiently implement a map using an unsorted list
  - We store the items of the map in a list S (based on a doubly-linked list), in arbitrary order



The get(k) Algorithm

```
Algorithm get(k):
    B = S.positions() {B is an iterator of the positions in S}
    while B.hasNext() do
        p = B.next()   { the next position in B }
        if p.element().getKey() = k        then
            return p.element().getValue()
    return null {there is no entry with key equal to k}
```

The put(k,v) Algorithm

```
Algorithm put(k,v):
B  = S.positions()
while B.hasNext() do
    p = B.next()
    if p.element().getKey() = k  then
        t = p.element().getValue()
        S.set(p,(k,v))
        return t        {return the old value}
S.addLast((k,v))
n = n + 1       {increment variable storing number of entries}
return null     { there was no entry with key equal to k }
```

The remove(k) Algorithm

```
Algorithm remove(k):
B =S.positions()
while B.hasNext() do
    p = B.next()
    if p.element().getKey() = k  then
        t = p.element().getValue()
        S.remove(p)
        n = n – 1      {decrement number of entries}
        return t       {return the removed value}
return null            {there is no entry with key equal to k}
```

Performance of a List-Based Map

- Performance:
  - put takes $O(n)$ time since we need to find out before adding the item if an entry with the key exists (in such case we only replace the value)
  - get and remove take $O(n)$ time since in the worst case (the item is not found) we traverse the entire sequence to look for an item with the given key
- The unsorted list implementation is effective only for maps of small sizes.