Searching Lists

Algorithms and Datastructures

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Outline

Arrays

Expandable arrays

Arrays are by nature of fixed length. How can we make them expandanble and still have direct memory access?

When adding a new element to a full array we could:

1. Copy the array to an array one bigger
2. Copy the array to an array m elements bigger
3. Copy the array to an array of double size

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3. $O(1)$ - how can that be?

Expandable arrays

Money in the bank

Balance: 4 we hope that is enough to pay for future expansions

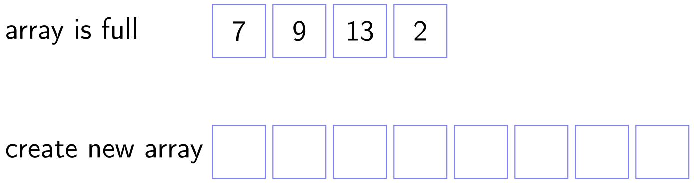
array is full

7	9	13	2

Expandable arrays

Money in the bank

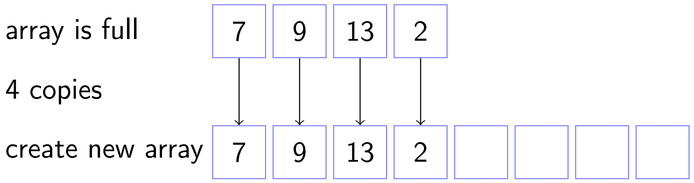
Balance: $4 - 0 = 4$ (creating new array considered free here)



Expandable arrays

Money in the bank

Balance: $4 - 4 = 0$ (using 1 per copy)



Expandable arrays

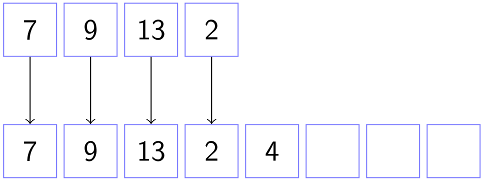
Money in the bank

Balance: $0 + 3 - 1 = 2$ (charging 3 for an insert, using 1)

array is full

4 copies

create new array



add element 4

Expandable arrays

Money in the bank

Balance: $2 + 3 - 1 = 4$ (charging 3 for an insert, using 1)

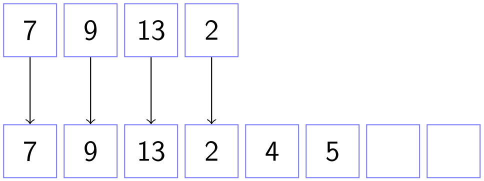
array is full

4 copies

create new array

add element 4

add element 5



Expandable arrays

Money in the bank

Balance: $4 + 3 - 1 = 6$ (charging 3 for an insert, using 1)

array is full

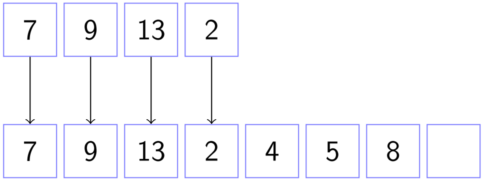
4 copies

create new array

add element 4

add element 5

add element 8



Expandable arrays

Money in the bank

Balance: $6 + 3 - 1 = 8$ (charging 3 for an insert, using 1)

array is full

4 copies

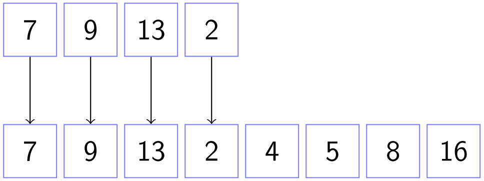
create new array

add element 4

add element 5

add element 8

add element 16



Expandable arrays

Money in the bank

Balance: 8 enough to pay for 8 copies

array is full

4 copies

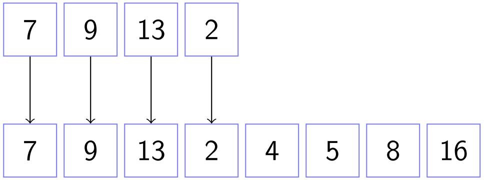
create new array

add element 4

add element 5

add element 8

add element 16



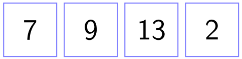
$O(3) = O(1)$

Expandable arrays

Constant payload

Payload: 0

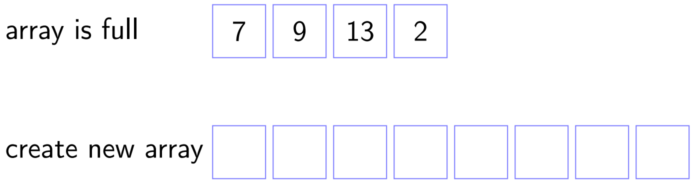
array is full



Expandable arrays

Constant payload

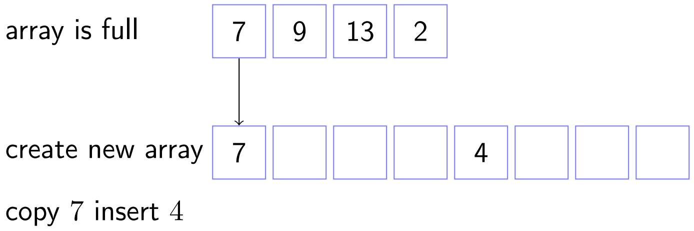
Payload: 0 (creating new array considered free here)



Expandable arrays

Constant payload

Payload: $1 + 1 = 2$ (1 for copying and 1 for inserting)



Expandable arrays

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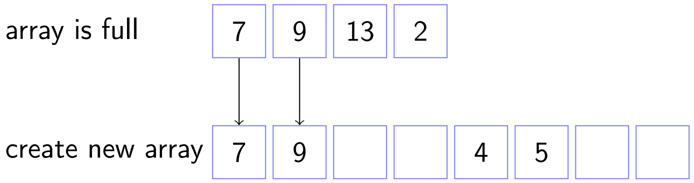


copy 7 insert 4

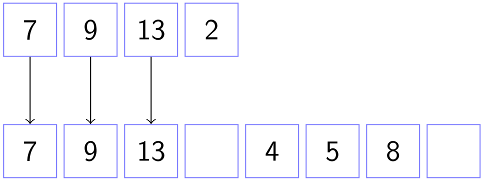
copy 9 insert 5

Expandable arrays

Constant payload

Payload: $1 + 1 = 2$ (1 for copying and 1 for inserting)

array is full



create new array

copy 7 insert 4

copy 9 insert 5

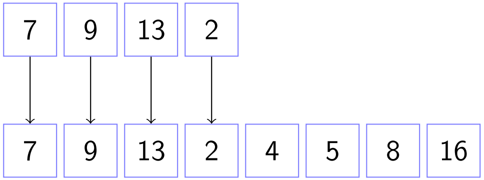
copy 13 insert 8

Expandable arrays

Constant payload

Payload: $1 + 1 = 2$ (1 for copying and 1 for inserting)

array is full



create new array

copy 7 insert 4

copy 9 insert 5

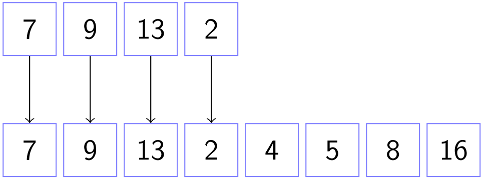
copy 13 insert 8

copy 2 insert 16

Expandable arrays

Constant payload

Payload: 8 in total for 4 insertions



copy 7 insert 4

copy 9 insert 5

copy 13 insert 8

copy 2 insert 16

$$O(2) = O(1)$$

Exercise 1 - Complexity

- What would the complexity (big-O) be if we:
  - Triple the array size instead of doubling it?
  - Only made the new array 50% bigger?
- Bearing in mind that most modern memory is paged[1], consider why doubling the array size is not such a bad idea?

[1]typically in 2^n sized pages

Exercise 2 - Implementation

1. Create a Java class `FlexibleArray` that uses the "Constant payload" algorithm.

   ```
   public class FlexibleArray<T> {
      ...
     public T get(int index) { ... }
     public void set(int index, T element) { ... }
     public void add(T element) { ... }
     public int size() { ...}
     }
   ```

   Note that to create a new array of type `T` you must:

   ```
   private T[] arrayOfT = (T[])new Object[1000];
   ```

2. Measure the time it takes to add 10.000, 100.000, and 1.000.000 elements.
3. Measure Javas build-in `ArrayList` with the same data.