Programming Languages and Techniques (CIS120)

Lecture 23

Oct 26, 2015

Resizable Arrays Demo

Java ASM

Announcements

- HW 06 due Thursday at midnight

- Midterm II, in class, a week from Friday (Nov 6th)

- Java Bootcamp
  - *TONIGHT* 6:00-8:00pm
  - Levine 100 (Wu & Chen)
  - Pizza!

What is the value of ans at the end of this program?

```
int[] a = {};
int ans = a.length;
```

1. 1
2. 2
3. 3
4. 0
5. NullPointerException
6. ArrayIndexOutOfBoundsException

Design Exercise: Resizable Arrays

Arrays that grow without bound.

The Java Abstract Stack Machine

Objects, Arrays, and Static Methods

Java Abstract Stack Machine

- Similar to OCaml Abstract Stack Machine
  - Workspace
    - Contains the currently executing code
  - Stack
    - Remembers the values of local variables and "what to do next" after function/method calls
  - Heap
    - Stores reference types: objects and arrays

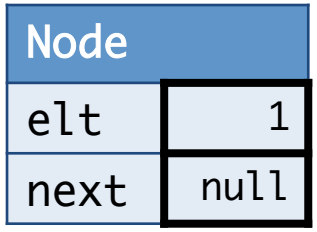
- Key differences:
  - Everything, including stack slots, is mutable by default
  - Heap objects store *dynamic class information*

Heap Values

Objects

- Name of the class that constructed it
- Values for all of the fields

```
class Node {
    private int elt;
    private Node next;
    …
}
```



fields may or may not be mutable

Arrays

- Type of values that it stores
- Length
- Values for all of the fields

```
int [] a = { 0, 0, 7, 0 };
```

length *never* mutable; elements *always* mutable

Resizable Arrays

Object Invariant: extent is always 1 past the last nonzero value in data (or 0 if the array is all zeros)

```
public class ResArray {

  /** Constructor, takes no arguments. */
  public ResArray() { … }

  /** Access the array at position i. If position i has not yet
   * been initialized, return 0.
   */
  public int get(int i) { … }

  /** Modify the array at position i to contain the value v. */
  public void set(int i, int v) { … }

  /** Return the extent of the array. */
  public int getExtent() { … }

}
```

ResArray ASM

Workspace

```
ResArray x = new ResArray();
x.set(3,2);
x.set(4,1);
x.set(4,0);
```

Stack

Heap

ResArray ASM

Workspace

```
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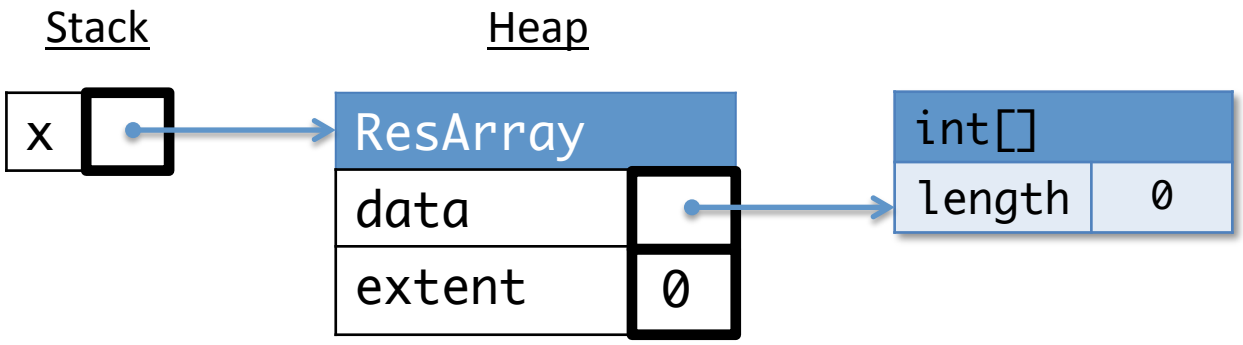

ResArray ASM

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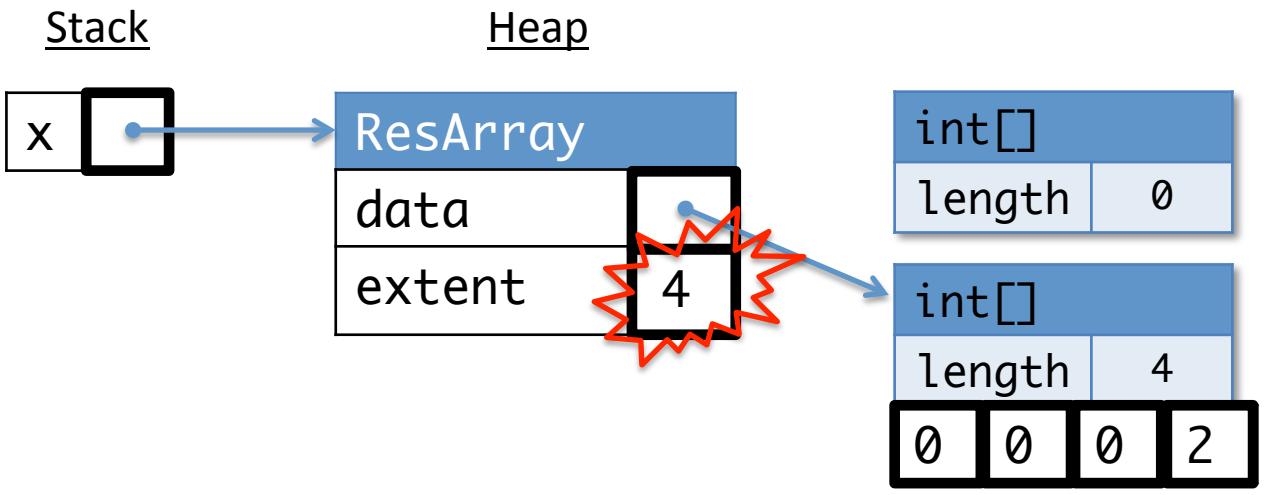

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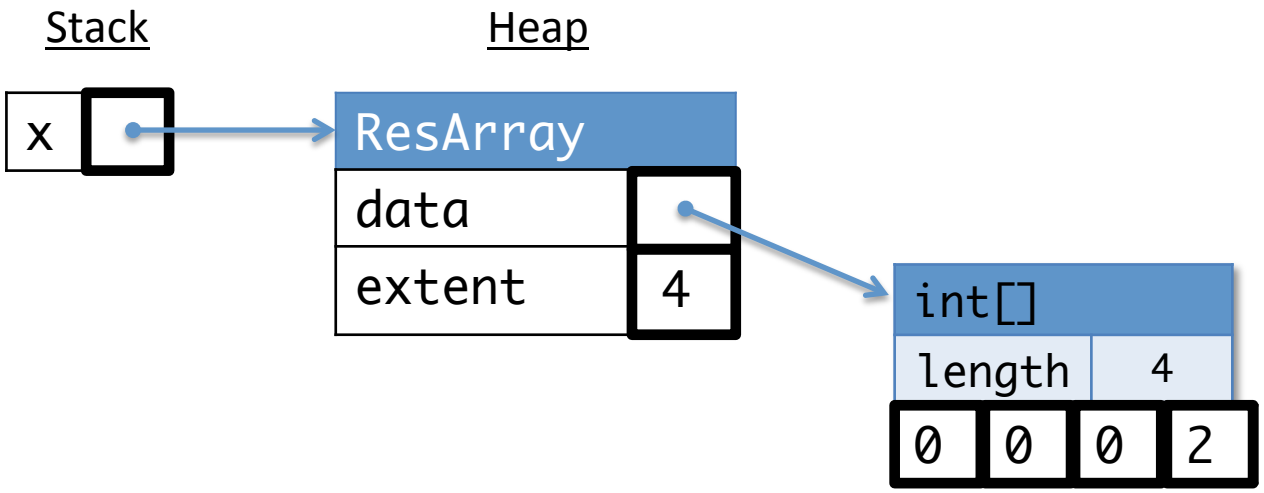

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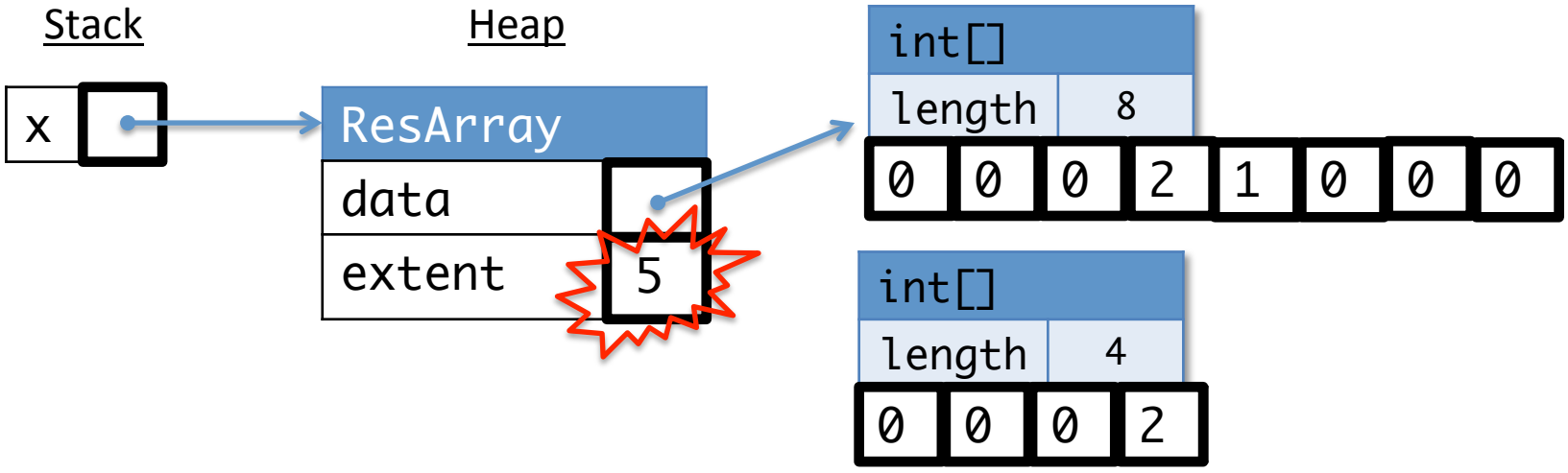

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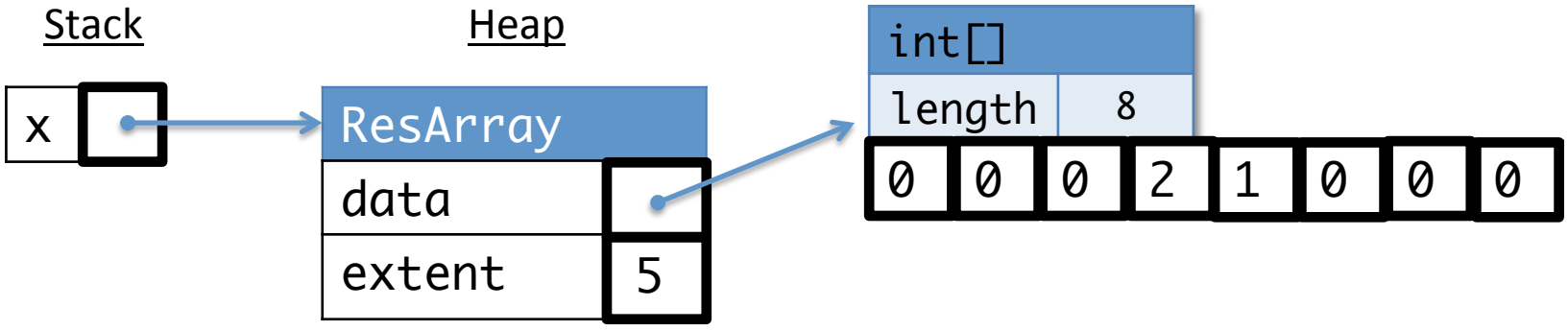

ResArray ASM

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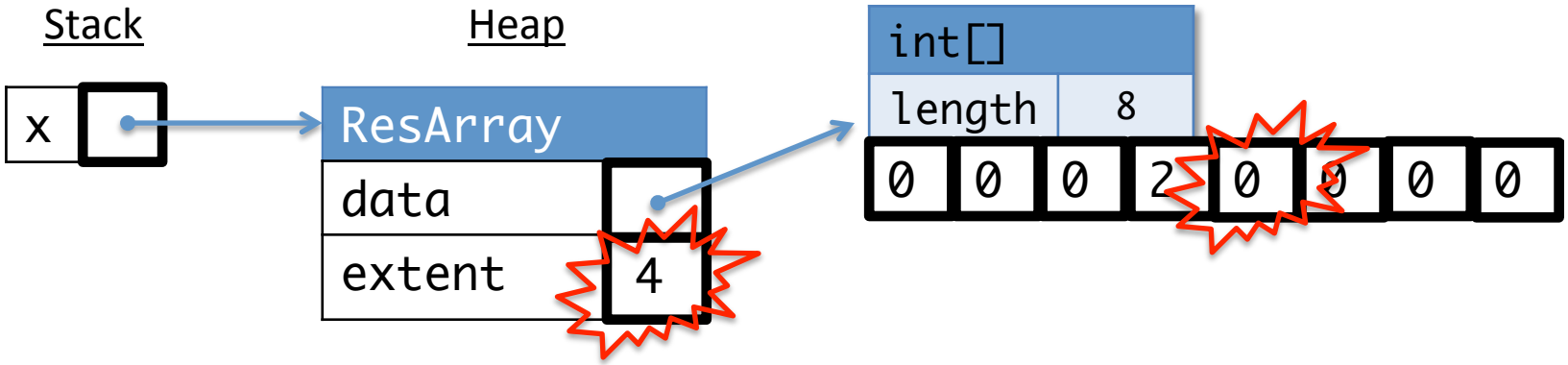

Resizable Arrays

Object Invariant: extent is always 1 past the last nonzero value in data (or 0 if the array is all zeros)

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  public int get(int i) { … }

  /** Modify the array at position i to contain the value v. */
  public void set(int i, int v) { … }

  /** Return the extent of the array. */
  public int getExtent() { … }

  /** The smallest prefix of the ResArray
   * that contains all of the nonzero values, as a normal array.
   */
  public int[] values() { … }
}
```

Values Method

```
public int[] values() {
    int[] values = new int[extent];
    for (int i=0; i<extent; i++) {
        values[i] = data[i];
    }
    return values;
}
```

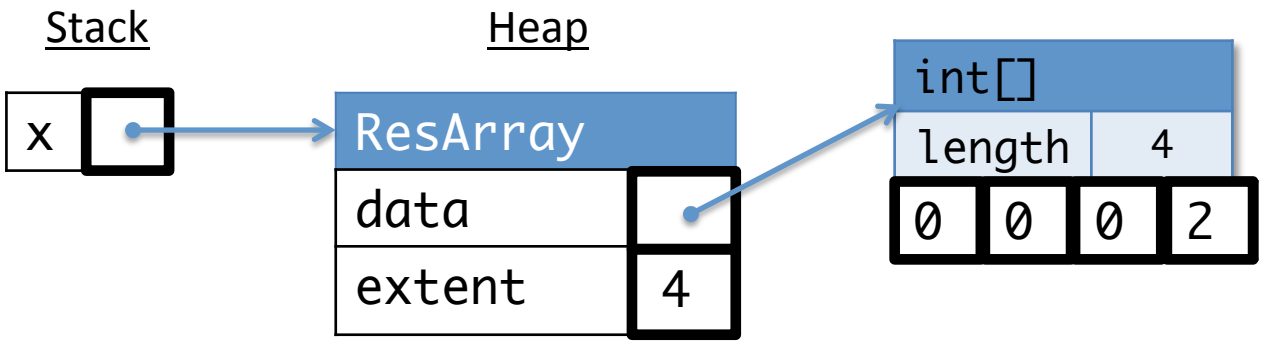
Or maybe we can do it more straightforwardly? …

```
public int[] values() {
    return data;
}
```

ResArray ASM

Workspace

```
ResArray x = new ResArray();
x.set(3,2);
int[] y = x.values();
y[3] = 0;
```



ResArray ASM

Workspace

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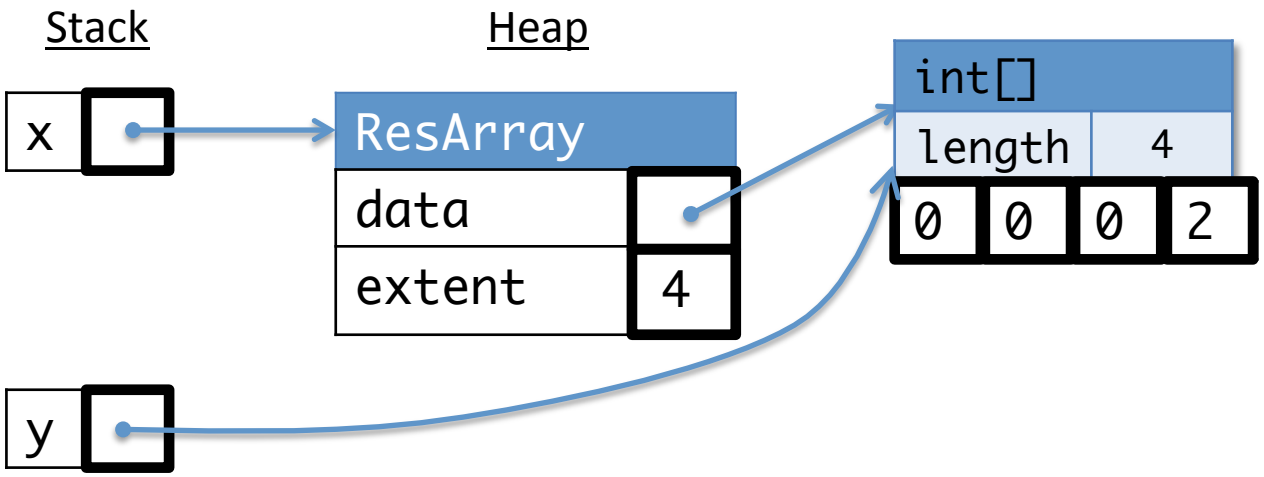

ResArray ASM

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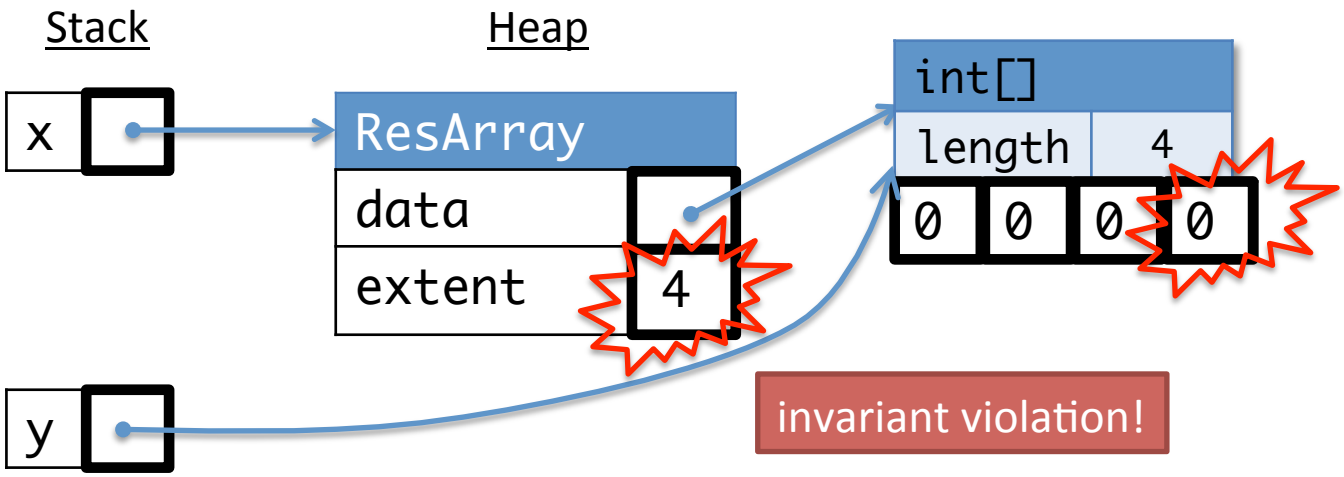

Object encapsulation

- All modification to the state of the object must be done using the object's own methods.
- Use encapsulation to preserve invariants about the state of the object.
- Enforce encapsulation by not returning aliases from methods.