Lecture 21: Switch, Break, Continue

Last time:
1. Continuation of Rational numbers
2. switch
3. break
4. Case continuation (or “fall through”)

Today:
1. break / continue
2. Intro to arrays
3. Copying arrays and making arrays bigger
4. Array lengths and out-of-bounds indexing

Why Use `switch`?

- `switch` can also be implemented using `if-else`
- `switch` also restricted in terms of data types in control statements
- Including `break` statements is a pain
- However
  - `switch` often more efficient (compiler generates better code)
  - Code can be more compact because of case-continuation behavior
  - Sometimes case analysis is clearer using `switch`

More about `break`

- `break` can also be used to exit immediately from any loop
  - `while`
  - `do-while`
  - `for`
- e.g. “Read numbers from input until negative number encountered”

```
Scanner sc = new Scanner (System.in);
int n;
while (true) {
   n = sc.nextInt ();
   if (n < 0)
         break;
   else
         <process n>;
}
```

  - Loop only terminates when `break` executed
  - This only happens when `n < 0`

Warning about `break`

- Undisciplined use of `break` can make loops impossible to understand
  - Termination of loops without `break` can be understood purely by looking `while`, `for` parts
  - When break included, arbitrary termination behavior can be introduced
- Rule of thumb: use `break` only when loop condition is always true (i.e. `break` is only way to terminate loop)

`continue` Statement

- `continue` can also be used to affect loops
  - `break` halts loops
  - `continue` jumps to bottom of loop body
- Following prints even numbers between 0 and 10

```
for (int i = 0; i <= 10; i++){
   if (i % 2 == 1)
     continue;
   System.out.println (i);
}
```

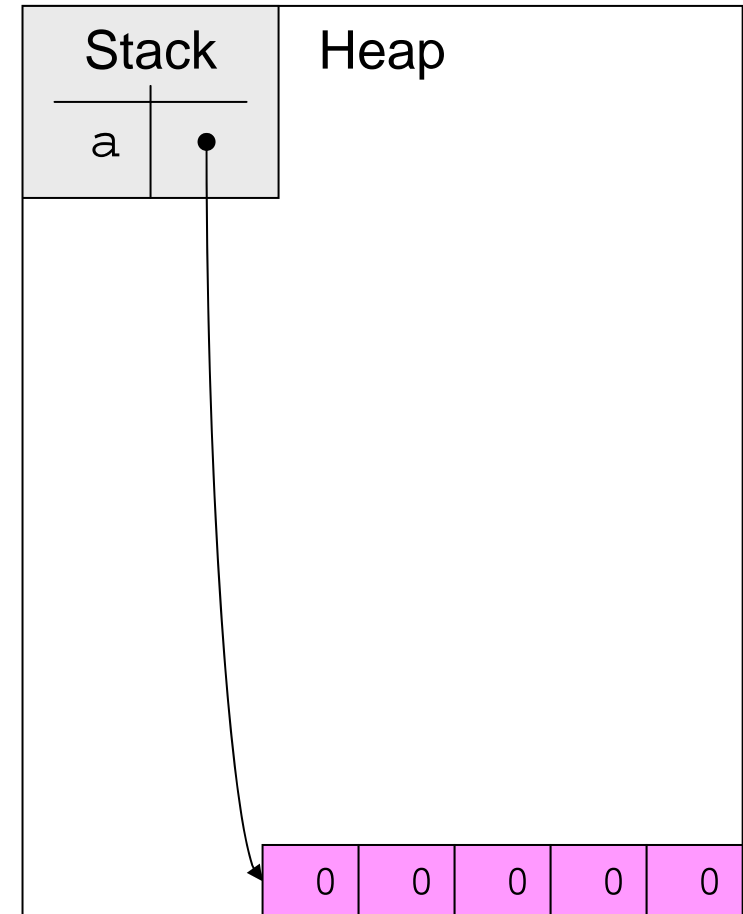
  - Effect of `continue` statement is to jump to bottom of loop immediately when `i` is odd
  - This bypasses `println`!
- `continue` should be avoided
  - Confusing
  - Easy equivalents exist (e.g. `if-else`)
  - Included in Java mainly for historical reasons

Data Structures and Arrays

- Data structures: mechanisms for storing data in a structured way
- We have seen simple data structures implemented as classes:
  - `Date.java`
    - "Date" data stored as month / day / year
    - Auxiliary data (e.g. separator) also stored
  - `Rational.java`
    - Rational number data stored as numerator / denominator pair
- Arrays are a very useful data structure provided by Java and other programming languages
  - Array: sequence of variables of the same type
  - Individual elements of sequence can be uniformly referenced / updated / etc.

Creating Arrays

- Arrays are objects (hence allocated on heap)
- To create an array, use `new`
- Java has special syntax for array type / constructor:
  `int[] a = new int[5];`
  - `int[]` indicates `a` is array of integer variables
  - `int[5]` indicates `a` will have 5 elements
- Like other objects, “instance variables” of array = cells in array are assigned default values (0 / null / etc.) when array created



Array Indexing

- Java provides a special syntax for uniformly accessing cells in an array
  - Assume previous declaration of a:

    ```
    int[] a = new int[5];
    ```
  - This in effect creates five `int` variables "named":

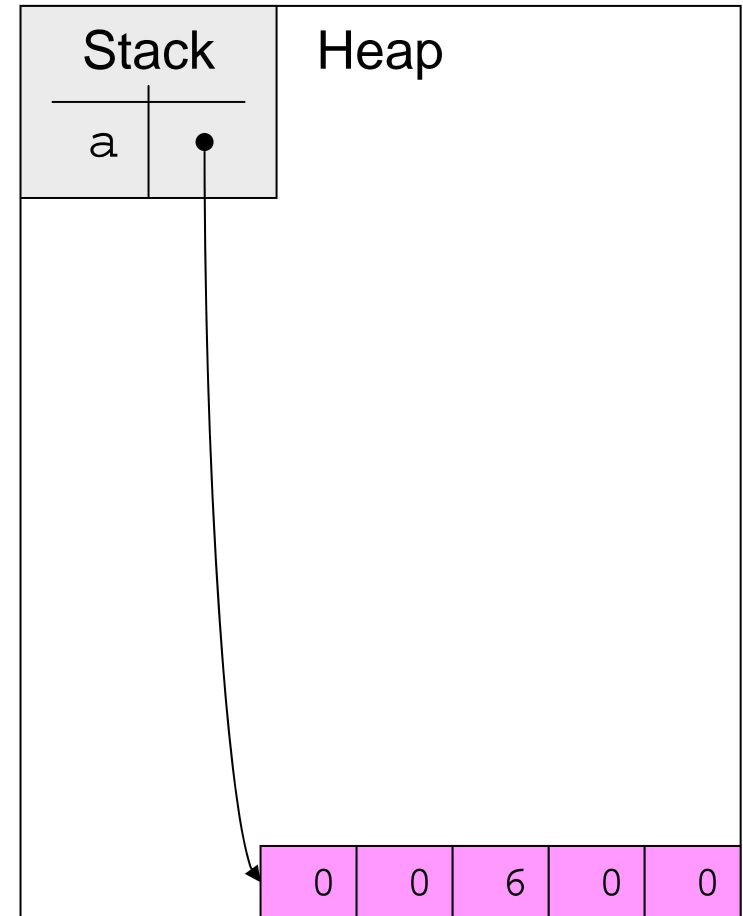
    ```
    a[0] a[1] a[2] a[3] a[4]
    ```
  - To modify contents of cell #2 to 6:

    ```
    a[2] = 6;
    ```
- This access mechanism is called array indexing
  - In Java / C / C++, array cells are indexed beginning at 0 and going up to n-1 (n is number of cells)
  - Beware of starting a 0!

Example

```
int[] a = new int[5];
```

```
a[2] = 6;
```



Loops Are Useful for Processing Arrays

- Loop counter can be used to iterate through index values
- Each iteration of loop thus processes a different array element
- See examples

A Common Programming Idiom

- To process all elements in array a…
- Do following:

```
for (int i = 0; i < a.length; i++){
  …a[i]…
}
```

  - Use fresh loop counter to avoid overwriting another variable of same name elsewhere
  - Use `i < a.length`, not `i <= a.length` (why?)

Copying Arrays

- Does the following copy a into b?

```
int[] a = new int[5];
int[] b = null;
b = a;
```

No: `a`, `b` are aliases

- How to make a copy? For now, use loop:

```
int[] a = new int[5];
int[] b = null;
b = new int[a.length];
for (int i = 0; i < a.length; i++)
  b[i] = a[i];
```

Making Arrays Bigger

- Suppose we want to make an array bigger by adding an element.
- Does the following work?

```
int[] a = new int[5];
a.length++;
```

- No!
  - We get the following:

```
Exception in thread "main" java.lang.Error:
  Unresolved compilation problem:
The final field array.length cannot be assigned
at Sample.main(Sample.java:15)
```

  - `a.length` is immutable
  - No assignment is allowed

To Make an Array Bigger…

- Create a new larger array object
- Copy old array contents into new object
- Assign address of new object to variable

```
int[] a = new int[5];
{
  int[] temp = new int[a.length + 1];
  for (int i = 0; i < a.length; i++)
      temp[i] = a[i];
  a = temp;
}
```

  - New variable temp created to hold copy
  - New block created to ensure temp does not interfere with another variable of the same name
  - Previous contents of a become garbage

More on Array Indexing

- Recall: if `a` is an array of `n` elements, then
  - Initial element is `a[0]`
  - Last element is `a[n-1]`
- Each array as an instance variable, `length`, storing the number of elements in the array
  - Consider:

    ```
    int[] a = new int[10];
    System.out.println (a.length);
    ```

  - `10` is printed
- What happens?

  ```
  int[] a = new int [10];
  a[10] = 0;
  ```

  - Error!

    ```
    Exception in thread "main" java.lang.ArrayIndexOutOfBoundsException: 10 at
    Sample.main(Sample.java:11)
    ```

  - The cells in a are `a[0], …, a[9]`
  - `a[10]` is like an undefined variable
- This kind of error is called an index out-of-bounds error
  - If you write `a[exp]` …
  - … and `exp` evaluates to something >= a.length …
  - … then Java reports an ArrayIndexOutOfBoundsException error