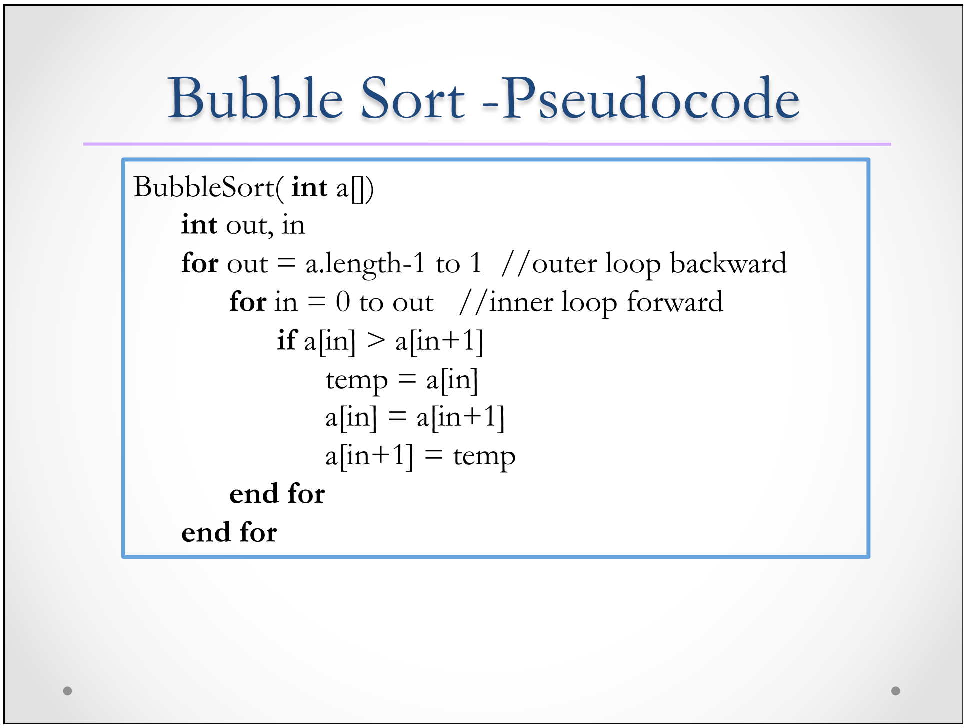
Simple Sorting

Bryn Mawr College
CS206 Intro to Data Structures

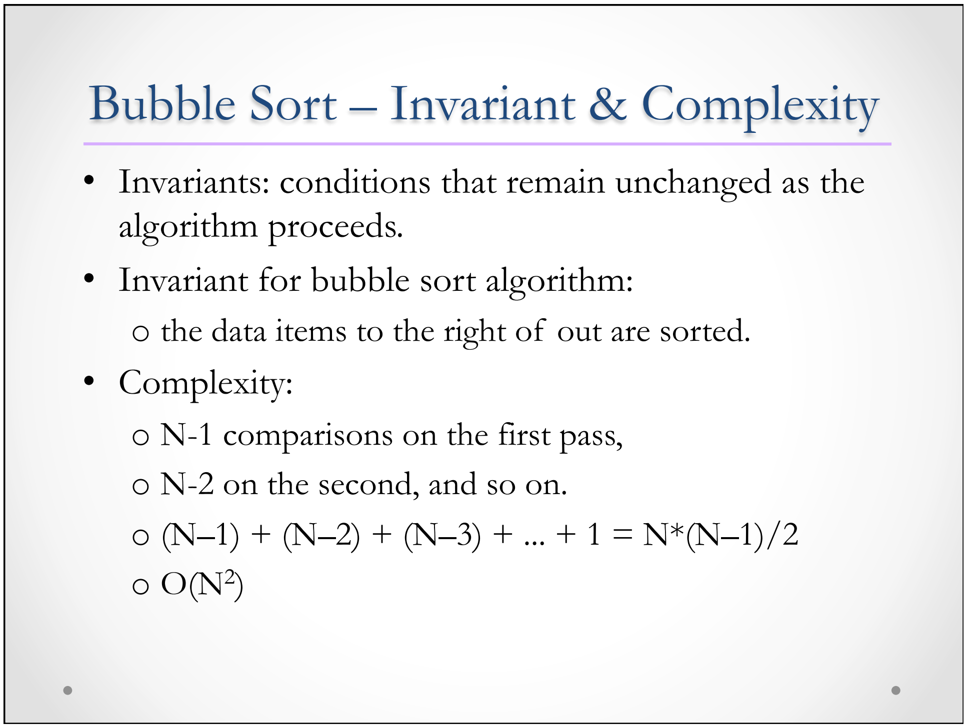
Bubble Sort

- Start at the left end of the array and compare the first two elements.
- If the one on the right is bigger, you don't do anything; otherwise, swap them.
- Move one position right.



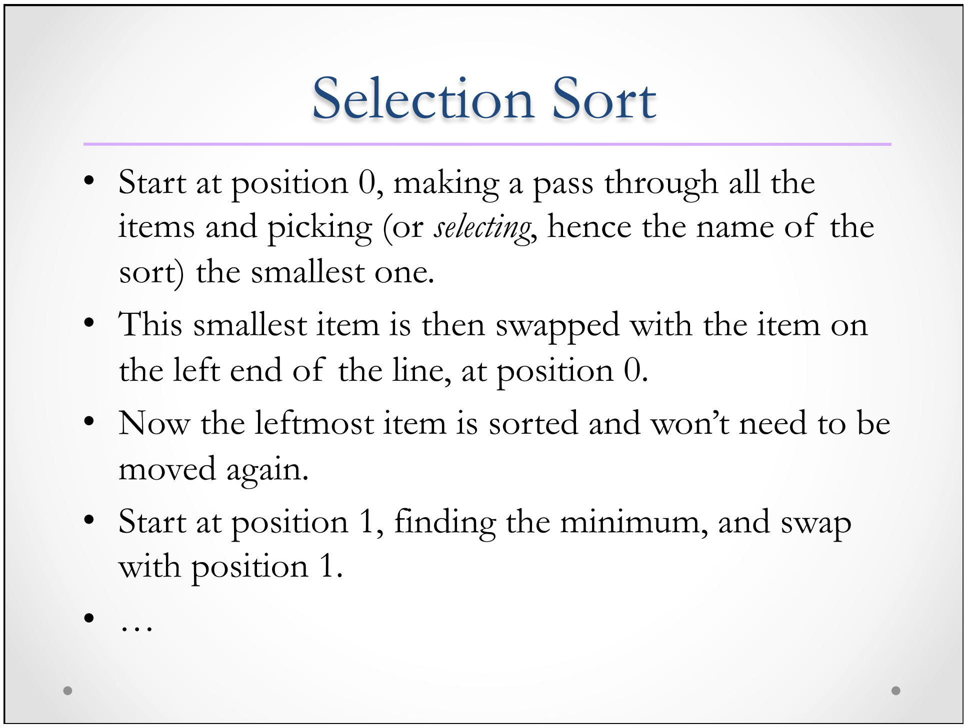
Bubble Sort -Pseudocode

```
BubbleSort( int a[])
    int out, in
    for out = a.length-1 to 1  //outer loop backward
        for in = 0 to out   //inner loop forward
            if a[in] > a[in+1]
                temp = a[in]
                a[in] = a[in+1]
                a[in+1] = temp
        end for
    end for
```



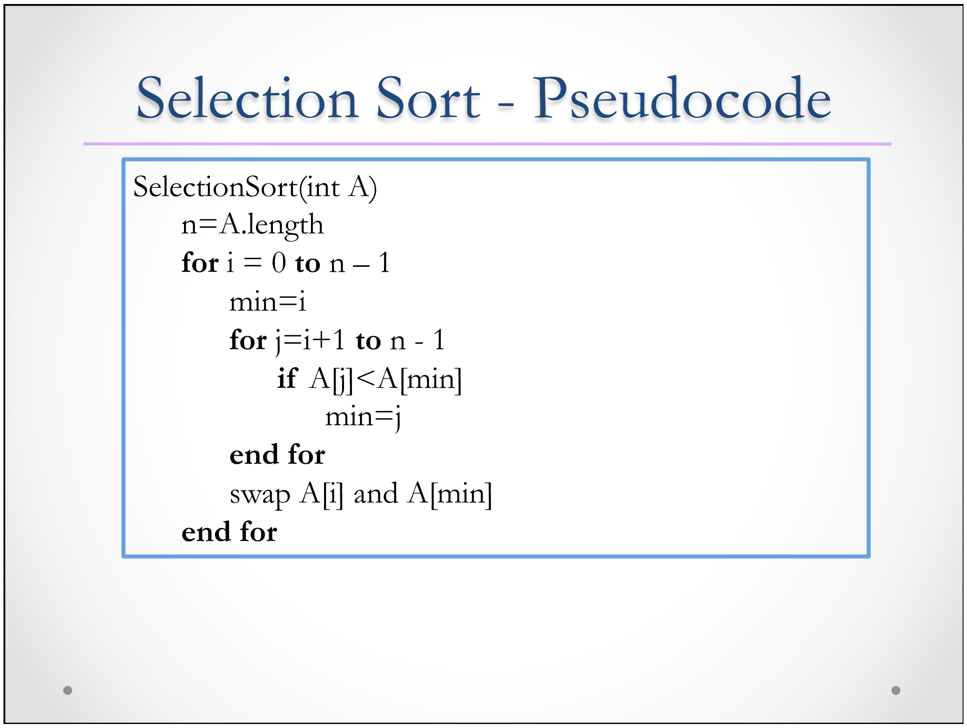
Bubble Sort – Invariant & Complexity

- Invariants: conditions that remain unchanged as the algorithm proceeds.
- Invariant for bubble sort algorithm:
  - the data items to the right of out are sorted.
- Complexity:
  - N-1 comparisons on the first pass,
  - N-2 on the second, and so on.
  - $(N-1) + (N-2) + (N-3) + ... + 1 = N*(N-1)/2$
  - $O(N^2)$



Selection Sort

- Start at position 0, making a pass through all the items and picking (or *selecting*, hence the name of the sort) the smallest one.
- This smallest item is then swapped with the item on the left end of the line, at position 0.
- Now the leftmost item is sorted and won't need to be moved again.
- Start at position 1, finding the minimum, and swap with position 1.
- …



Selection Sort - Pseudocode

```
SelectionSort(int A)
    n=A.length
    for i = 0 to n – 1
        min=i
        for j=i+1 to n - 1
            if  A[j]<A[min]
                min=j
        end for
        swap A[i] and A[min]
    end for
```

Selection Sort – Invariant & Complexity

- Invariant:
  - The data items with indices less than or equal to i are always sorted.
- Complexity:
  - N*(N–1)/2
  - O(N^2)
- Selection sort vs. bubble sort:
  - O(N^2) comparison performed
  - O(N) swaps

Insertion Sort

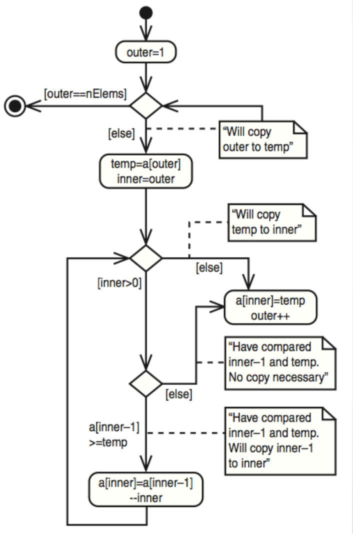
- Idea:

```
for i = 1 to n − 1:
    insert A[i] in its proper place amongst A[0..i].
```

- Example
  - 4 **3** 2 1 → 3 4 **2** 1 → 2 3 4 **1** → 1 2 3 4
- Note that inserting A[i] in the correct place implies shifting up some, maybe all, elements of A[0 .. i−1] to make room for A[i].

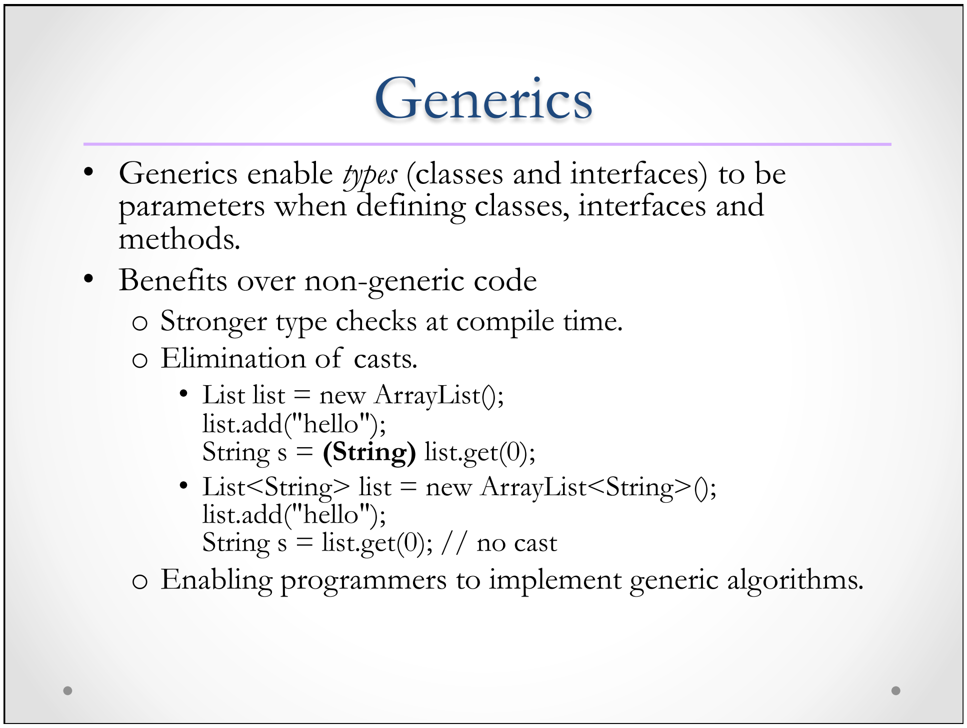
Insertion Sort – Pseudocode

```
InsertionSort(int A)
    n=A.length
    for out = 1 to n – 1
        temp = A[out]
        in = out
        while in>0 and A[in-1]>=temp
            A[in] = A[in - 1]
            in--
        end while
        A[in] = temp
    end for
```



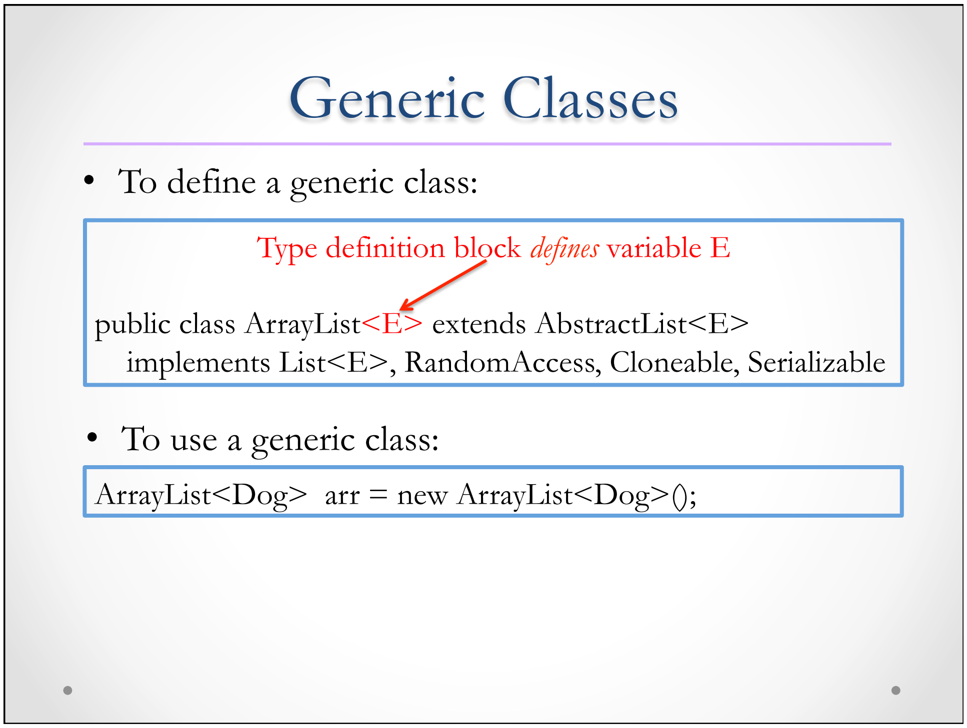
Insertion Sort – Invariant & Complexity

- Invariant:
    - At the start of iteration i of the outer loop, subarray A[0..i-1] consists of the elements originally in A[0..i-1], but in sorted order.
    - At termination, i=n, so the invariant implies that subarray A[0..n—1] (i.e., the *whole* array) consists of the elements originally in A[0..n—1], but in sorted order. (correctness of insertion sort)
- Complexity
    - Outer loop: n iterations
    - Inner loop: <= n iterations
    - Per iteration: constant amount of work
    - O(N^2)



Generics

- Generics enable *types* (classes and interfaces) to be parameters when defining classes, interfaces and methods.
- Benefits over non-generic code
  - Stronger type checks at compile time.
  - Elimination of casts.
    - List list = new ArrayList();
      list.add("hello");
      String s = **(String)** list.get(0);
    - List<String> list = new ArrayList<String>();
      list.add("hello");
      String s = list.get(0); // no cast
  - Enabling programmers to implement generic algorithms.



Generic Classes

- To define a generic class:

Type definition block *defines* variable E

public class ArrayList<E> extends AbstractList<E>
  implements List<E>, RandomAccess, Cloneable, Serializable

- To use a generic class:

ArrayList<Dog> arr = new ArrayList<Dog>();

Defining Generic Classes and Interfaces

```
public class Pair<E> {
   private E first;
   private E second;
   public Pair(E first, E second) {
      this.first = first;
      this.second = second;
   }
}
```

```
public interface
Comparator<T>
{
   int compare(T lhs, T rhs);
}
```

we can use the Pair class by providing a concrete type:

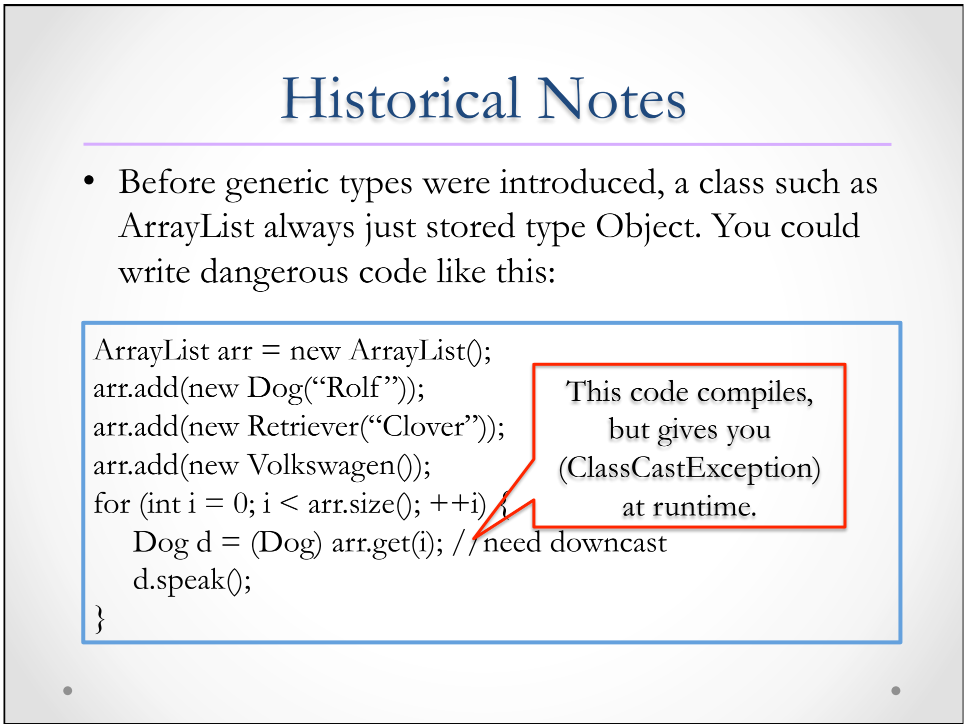
-
  ```
  Dog d = new Dog("Rolf", null);
  Retriever r =new Retriever("Clover", null);
  Pair<Pet> petPair = new Pair<Pet>(d, r);
  ```

Scope of Type Variables

- You can use a type variable throughout the class (including in the class declaration itself).
- You cannot refer to it in a static method or declare static variables of that type:

```
public class MyClass<T> implements Iterable<T>{
    private T foo;  //OK

   // Compile error: “Cannot make a static
   // reference to the non-static type T”
   private static T bar;
}
```

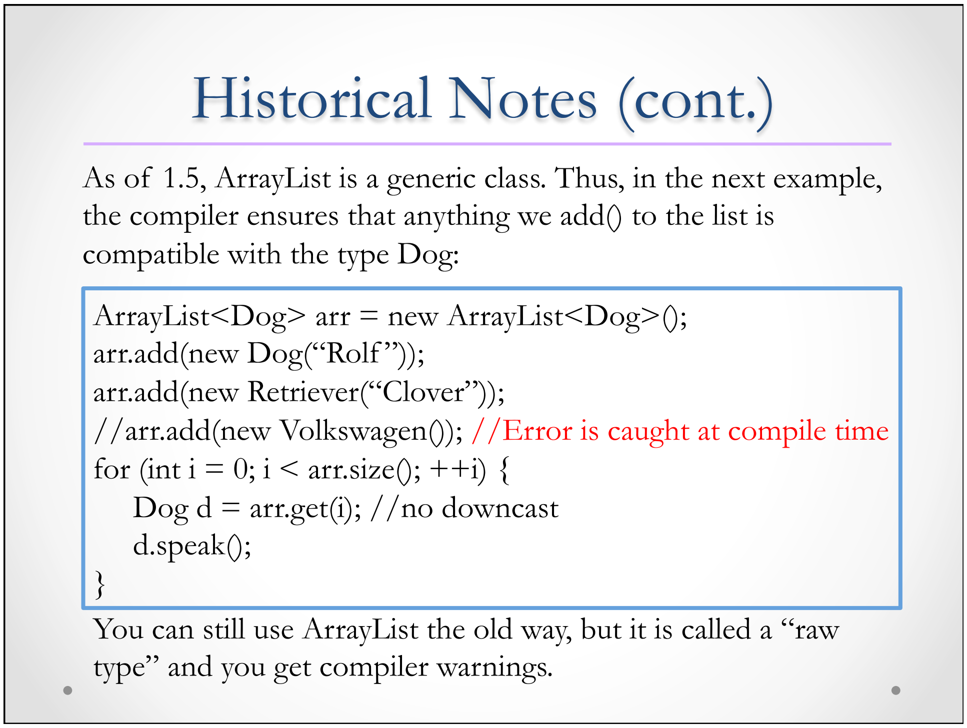


Historical Notes

- Before generic types were introduced, a class such as ArrayList always just stored type Object. You could write dangerous code like this:

```
ArrayList arr = new ArrayList();
arr.add(new Dog(“Rolf”));
arr.add(new Retriever(“Clover”));
arr.add(new Volkswagen());
for (int i = 0; i < arr.size(); ++i) {
    Dog d = (Dog) arr.get(i); //need downcast
    d.speak();
}
```

This code compiles, but gives you (ClassCastException) at runtime.



Historical Notes (cont.)

As of 1.5, ArrayList is a generic class. Thus, in the next example, the compiler ensures that anything we add() to the list is compatible with the type Dog:

```
ArrayList<Dog> arr = new ArrayList<Dog>();
arr.add(new Dog(“Rolf”));
arr.add(new Retriever(“Clover”));
//arr.add(new Volkswagen()); //Error is caught at compile time
for (int i = 0; i < arr.size(); ++i) {
    Dog d = arr.get(i); //no downcast
    d.speak();
}
```

You can still use ArrayList the old way, but it is called a “raw type” and you get compiler warnings.