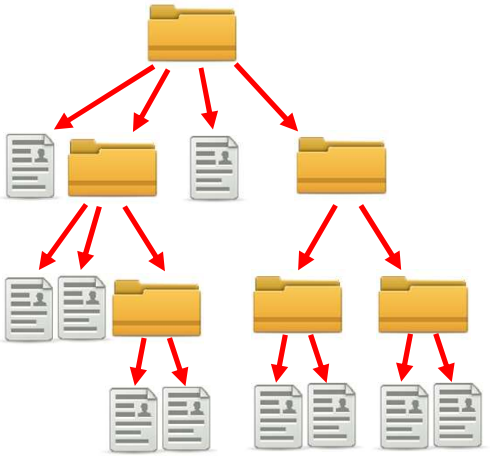
LESSON 6
COMPOSITE PATTERN
ITERATOR PATTERN

Composite pattern

- The intent of this pattern is to compose objects into tree structures to represent part-whole hierarchies.
- Composite lets clients treat individual objects and compositions of objects uniformly.

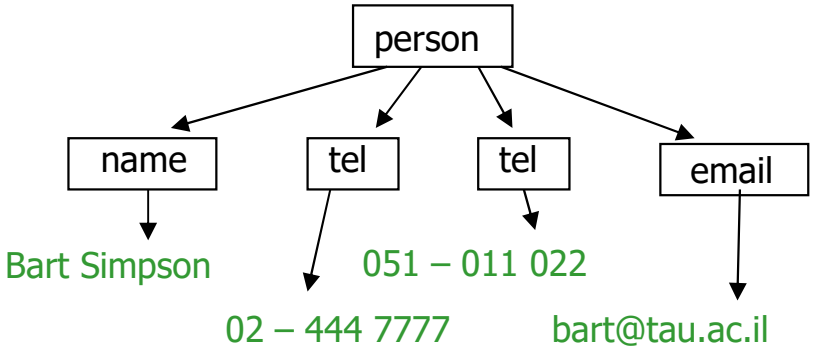
Tree structures

File system

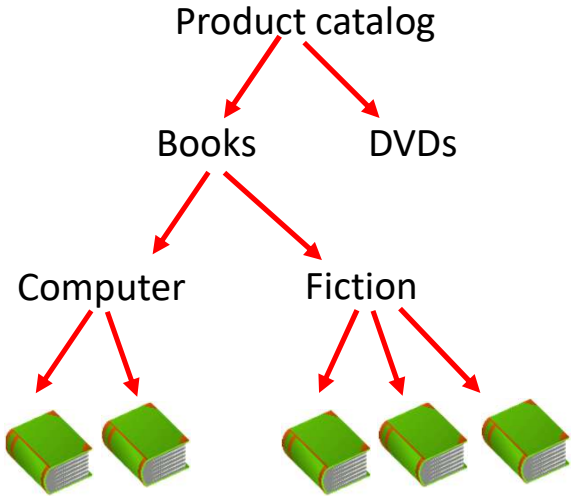


XML structure

```
<person>
  <name> Bart Simpson </name>
  <tel> 02 – 444 7777 </tel>
  <tel> 051 – 011 022 </tel>
  <email> bart@tau.ac.il </email>
</person>
```

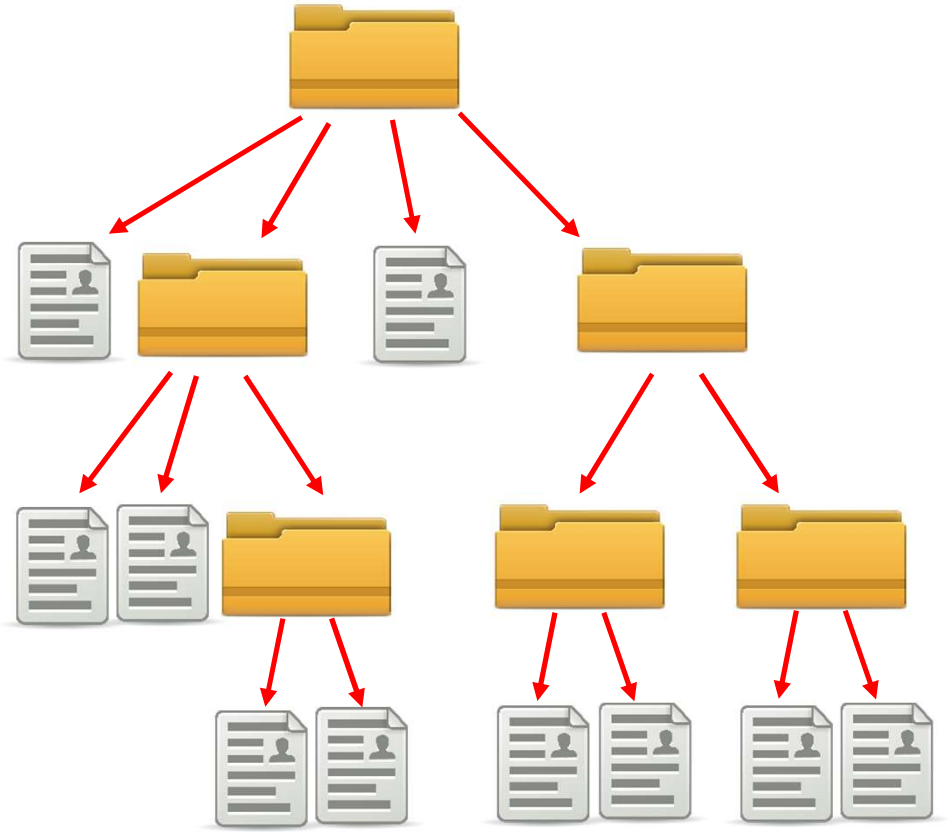


Product catalog

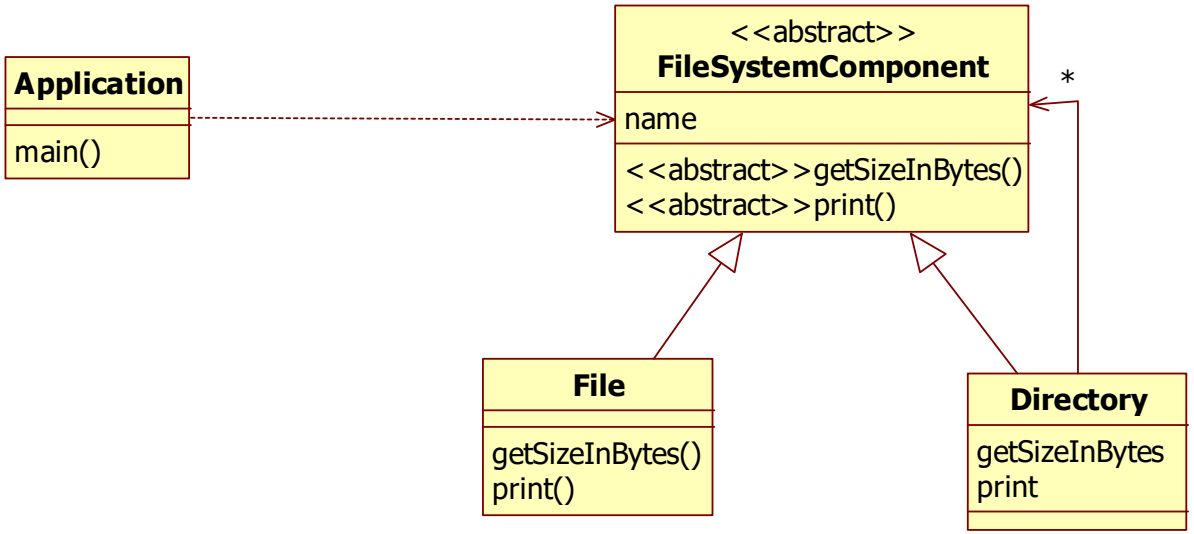


Example application

- Filesystem
  - Common functionality
    - Compute the size
    - Print whole directory



Composite pattern



FileSystemComponent & File

```
public abstract class FileSystemComponent {
  protected String name;

  public FileSystemComponent(String name) {
    this.name = name;
  }

  public abstract void print();

  public abstract int getSizeInBytes();
}
```

```
public class File extends FileSystemComponent {
  private int sizeInBytes;

  public File(String name, int sizeInBytes) {
    super(name);
    this.sizeInBytes = sizeInBytes;
  }

  public int getSizeInBytes() {
    return sizeInBytes;
  }

  public void print() {
    System.out.println("--- file " + name + " size=" +
           getSizeInBytes() + " bytes");
  }
}
```

Directory

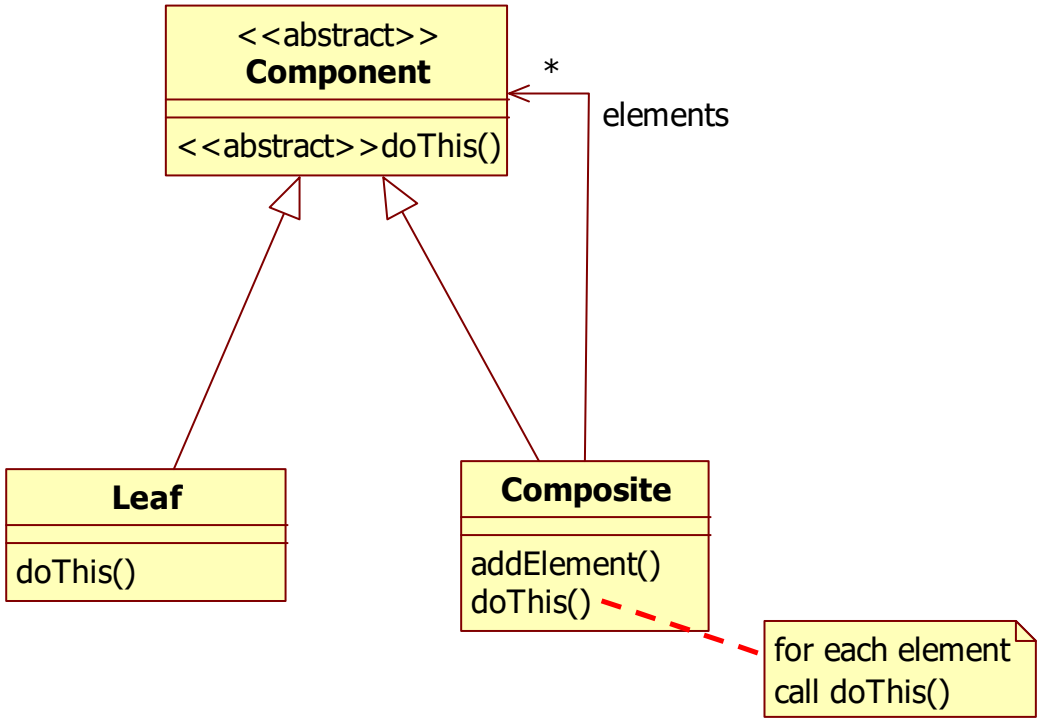
```
public class Directory extends FileSystemComponent {
  protected Collection<FileSystemComponent> fileSystemComponents = new
                          ArrayList<FileSystemComponent>();

  public Directory(String name) {
    super(name);
  }

  public void addComponent(FileSystemComponent component) {
    fileSystemComponents.add(component);
  }

  public int getSizeInBytes() {
    int sizeInBytes = 0;
    for (FileSystemComponent component : fileSystemComponents) {
      sizeInBytes += component.getSizeInBytes();
    }
    return sizeInBytes;
  }

  public void print() {
    System.out.println("-- dir " + name + " size=" + getSizeInBytes() + " bytes");
    for (FileSystemComponent component : fileSystemComponents) {
      component.print();
    }
  }
}
```

The application

```
public class Application {

  public static void main(String[] args) {
    Directory cdir = new Directory("C");
    Directory appdir = new Directory("applications");
    Directory datadir = new Directory("my data");
    Directory coursedir = new Directory("cs525");
    File excelfile = new File("msexcel.exe", 2353256);
    File wordfile = new File("msword.exe", 3363858);
    File studentsfile = new File("students.doc", 34252);
    cdir.addComponent(appdir);
    cdir.addComponent(datadir);
    datadir.addComponent(coursedir);
    appdir.addComponent(excelfile);
    appdir.addComponent(wordfile);
    coursedir.addComponent(studentsfile);
    cdir.print();
  }
}
```

```
-- dir C size=5751366 bytes
-- dir applications size=5717114 bytes
--- file msexcel.exe size=2353256 bytes
--- file msword.exe size=3363858 bytes
-- dir my data size=34252 bytes
-- dir cs525 size=34252 bytes
--- file students.doc size=34252 bytes
```

Composite structure



Composite pattern

- What problem does it solve?
  - Composite can be used when clients should ignore the difference between compositions of objects and individual objects.
  - If programmers find that they are using multiple objects in the same way, and often have nearly identical code to handle each of them, then composite is a good choice; it is less complex in this situation to treat primitives and composites as homogeneous.

Main point

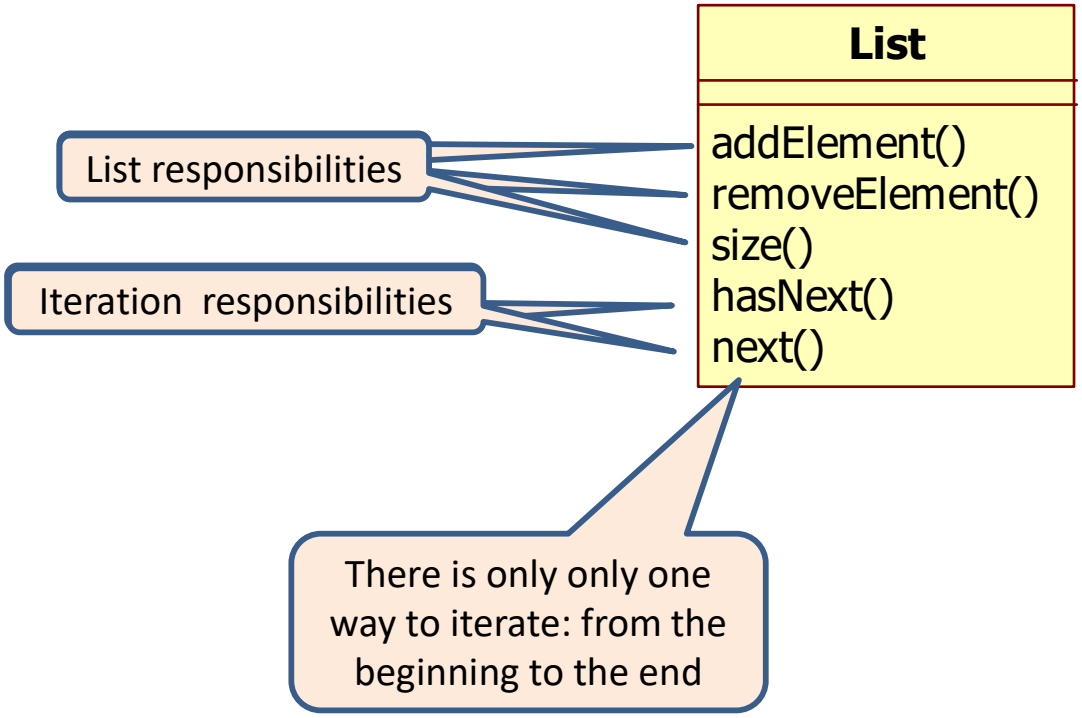
- The composite pattern can be used to represent tree structures.
- The structure of the universe emerges from pure consciousness which is the basis of all life.

ITERATOR PATTERN

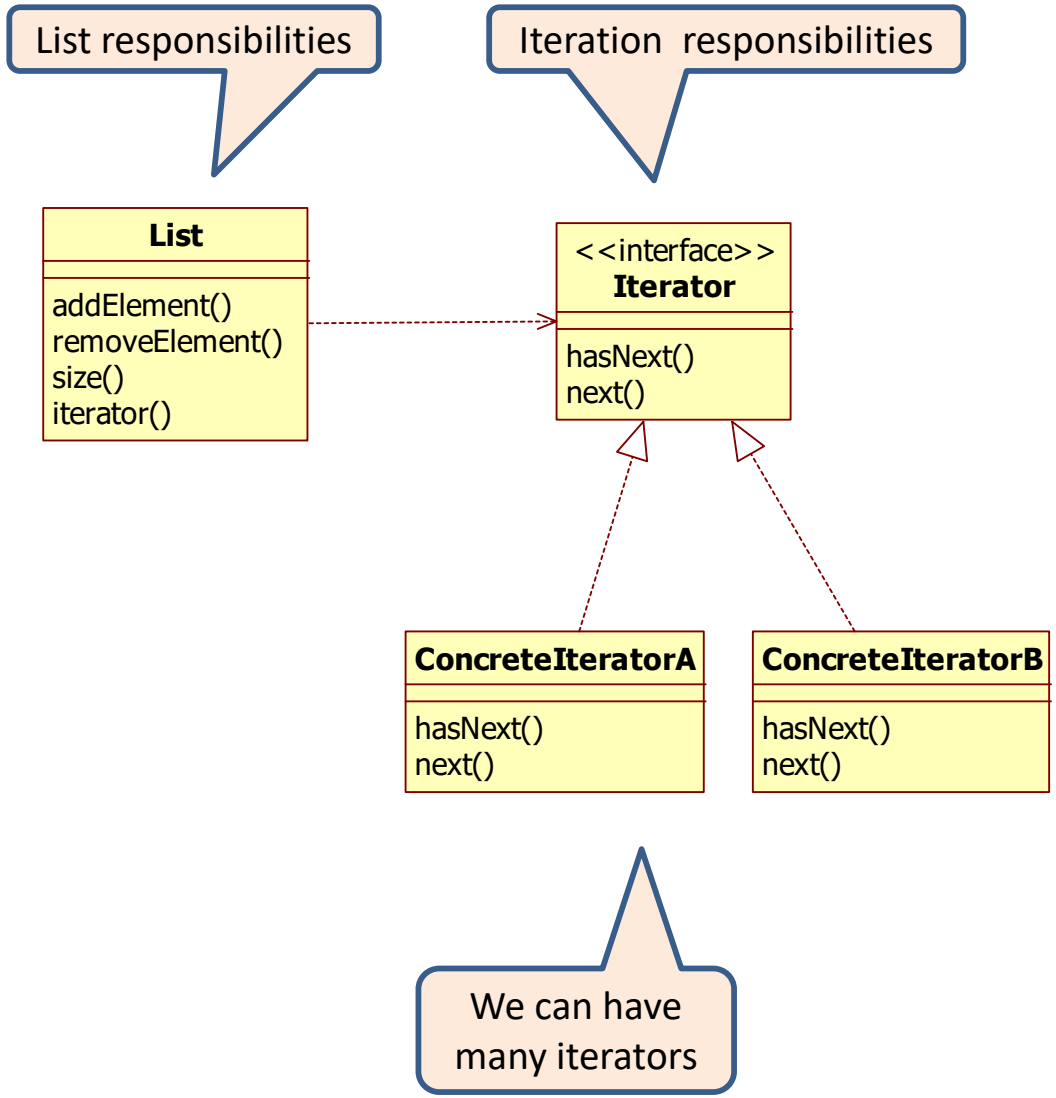
Iterator pattern

- Iterators are used to access the elements of an aggregate object sequentially without exposing its underlying implementation.
- An iterator object encapsulates the internal structure of how the iteration occurs.

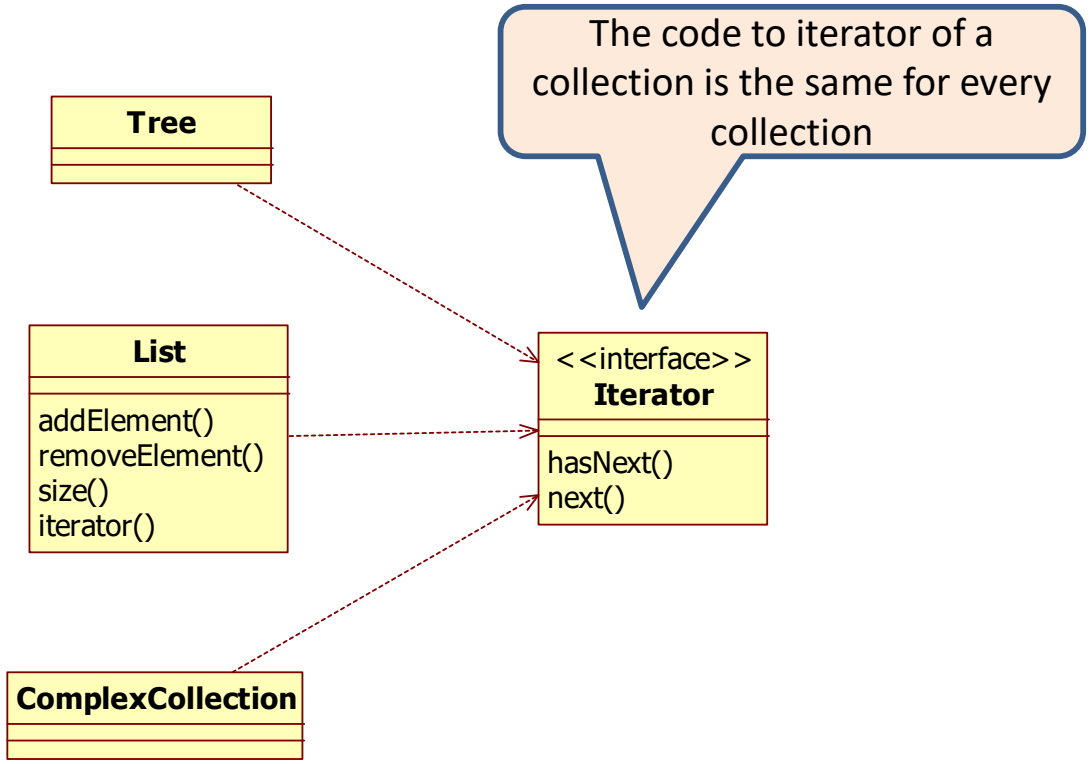
Without the Iterator pattern



With the Iterator pattern



With the Iterator pattern



Iterators

- External iterator
- The client controls the iteration

- Internal iterator
- The iterator controls the iteration

External iteration in Java

```
public class ApplicationForEach {

  public static void main(String[] args){
    List<String> alphabet = new ArrayList<String>();
    alphabet.add("a");
    alphabet.add("b");
    alphabet.add("c");

    Iterator<String> iterator = alphabet.listIterator();
    while (iterator.hasNext()) {
      System.out.println(iterator.next().toUpperCase());
    }
  }
}
```

External iterator

Enhanced for loop iteration in Java

```
public class ApplicationForEach {

  public static void main(String[] args){
    List<String> alphabet = new ArrayList<String>();
    alphabet.add("a");
    alphabet.add("b");
    alphabet.add("c");

    for(String letter: alphabet){
      System.out.println(letter.toUpperCase());
    }
  }
}
```

The underlying code which makes this iteration work uses an external iterator and calls next() and hasNext() methods

Internal iteration in Java

```
public class ApplicationInternalIterator {

  public static void main(String[] args) {
    List<String> alphabet = new ArrayList<String>();
    alphabet.add("a");
    alphabet.add("b");
    alphabet.add("c");

    alphabet.forEach(l -> System.out.println(l.toUpperCase()));
  }
}
```

Internal iterator

Removing an element from a collection

```
public class ApplicationForEachException {

  public static void main(String[] args){
    List<String> alphabet = new ArrayList<String>();
    alphabet.add("a");
    alphabet.add("b");
    alphabet.add("c");

    for(String letter: alphabet){
      if (letter.equals("c"))
        alphabet.remove(letter);
    }
  }
}
```

ConcurrentModificationException

```
Exception in thread "main" java.util.ConcurrentModificationException
at java.util.ArrayList$Itr.checkForComodification(ArrayList.java:909)
at java.util.ArrayList$Itr.next(ArrayList.java:859)
at removing.with.iterator.ApplicationForEachException.main(ApplicationForEachException.java:15)
```

Removing an element from a collection

```
public class ApplicationInternalIterator {

  public static void main(String[] args) {
    List<String> alphabet = new ArrayList<String>();
    alphabet.add("a");
    alphabet.add("b");
    alphabet.add("c");

    alphabet.forEach(l -> {if (l.equals("c"))   alphabet.remove(l);});
    alphabet.forEach(l -> System.out.println(l.toUpperCase()));
  }
}
```

ConcurrentModificationException

```
Exception in thread "main" java.util.ConcurrentModificationException
at java.util.ArrayList.forEach(ArrayList.java:1260)
at removing.with.iterator.ApplicationInternalIterator.main(ApplicationInternalIterator.java:15)
```

Removing an element from a collection

```
public class ApplicationForEachSuccess {

  public static void main(String[] args){
    String toBeRemoved = null;
    List<String> alphabet = new ArrayList<String>();
    alphabet.add("a");
    alphabet.add("b");
    alphabet.add("c");

    for(String letter: alphabet){
      if (letter.equals("c"))
        toBeRemoved=letter;
    }
    alphabet.remove(toBeRemoved);

    for(String letter: alphabet){
      System.out.println(letter.toUpperCase());
    }

  }
}
```

Call remove() outside the loop

Removing an element from a collection

```
public class ApplicationExternalIterator {

  public static void main(String[] args) {
    List<String> alphabet = new ArrayList<String>();
    alphabet.add("a");
    alphabet.add("b");
    alphabet.add("c");

    Iterator<String> iterator = alphabet.listIterator();
    while (iterator.hasNext()) {
      String element = iterator.next();
      if (element.equals("c"))
        iterator.remove();
    }

    iterator = alphabet.listIterator();
    while (iterator.hasNext()) {
      System.out.println(iterator.next().toUpperCase());
    }
  }
}
```

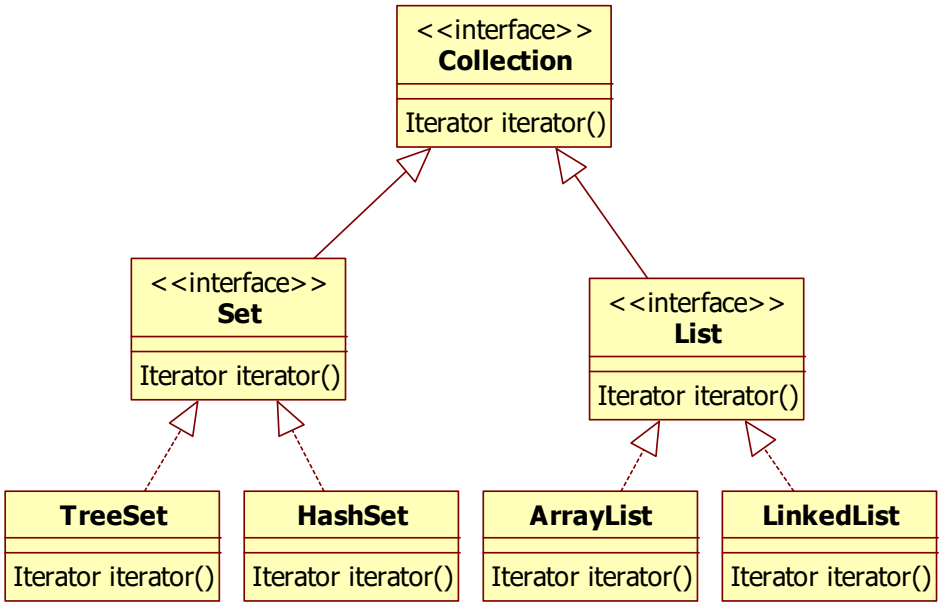
Call remove() on the iterator

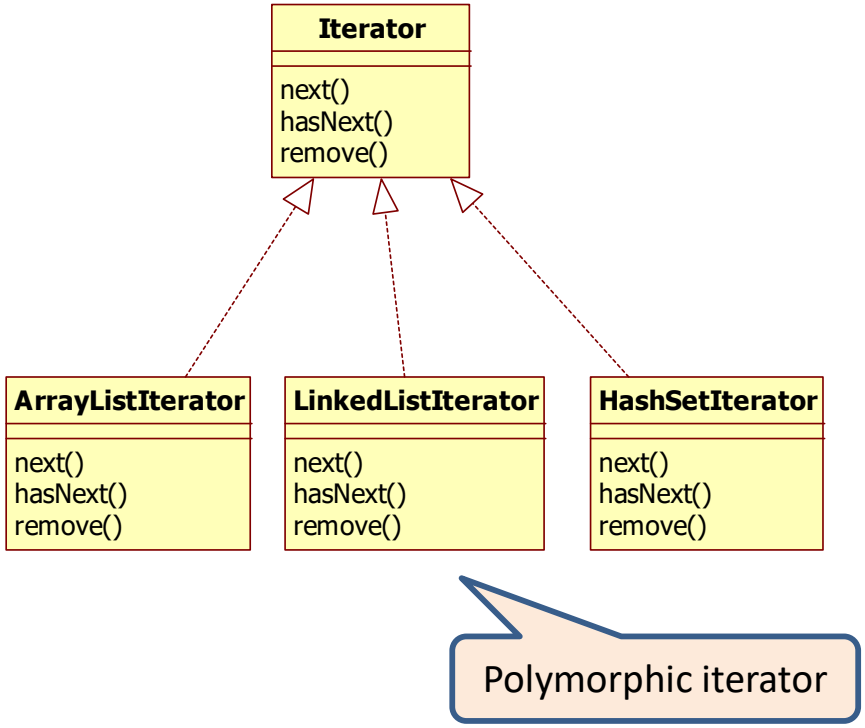
Removing an element from a collection

```
public class ApplicationInternalIteratorSuccess {

  public static void main(String[] args) {
    List<String> alphabet = new ArrayList<String>();
    alphabet.add("a");
    alphabet.add("b");
    alphabet.add("c");

    alphabet.removeIf(l -> l.equals("c"));

    alphabet.forEach(l -> System.out.println(l.toUpperCase()));
  }
}
```

removeIf() uses the internal iterator

Iterator in Java collection framework





Iterator in Java collection framework

```
public class Application {
  public static void main(String[] args) {
    Collection<String> col1 = new ArrayList<>();
    col1.add("a");
    col1.add("b");
    col1.add("c");
    Collection<String> col2 = new HashSet<>();
    col1.add("a");
    col1.add("b");
    col1.add("c");
    Collection<String> col3 = new LinkedList<>();
    col1.add("a");
    col1.add("b");
    col1.add("c");
    printCollection(col1);
    printCollection(col2);
    printCollection(col3);
  }

  public static void printCollection(Collection<String> collection) {
    Iterator<String> iterator = collection.iterator();
    while (iterator.hasNext()) {
      System.out.println(iterator.next());
    }
  }

}
```

Polymorphic iterator

Writing your own iterator

```
public class ReverseIterator<T> implements Iterator<T>{
  private final List<T> list;
  private int position;

  public ReverseIterator(List<T> list) {
    this.list = list;
    this.position = list.size() - 1;
  }

  public Iterator<T> iterator() {
    return this;
  }

  @Override
  public boolean hasNext() {
    return position >= 0;
  }

  @Override
  public T next() {
    return list.get(position--);
  }

  @Override
  public void remove() {
    throw new UnsupportedOperationException();
  }
}
```

Implement the Iterator interface

Iterate from the back to the front of the list

Not supported

Using your own iterator

```
public class ProductCollection {
  private List<Product> products = new ArrayList<>();

  public void addProduct(Product product){
    products.add(product);
  }

  public Iterator<Product> reverseIterator(){
    return new ReverseIterator<Product>(products);
  }
}
```

Factory method creates the iterator

```
public class Product {
  private String number;
  private String name;
  private double price;
  private boolean available;
  ...
}
```

Using your own iterator

```
public class Application {

  public static void main(String[] args) {
    ProductCollection productCollection = new ProductCollection();
    productCollection.addProduct(new Product("A234", "Iphone 10", 850.0, true));
    productCollection.addProduct(new Product("A235", "Iphone 11", 1050.0, false));
    productCollection.addProduct(new Product("A236", "Iphone 9", 650.0, true));
    productCollection.addProduct(new Product("A238", "Iphone 8", 425.0, true));


    Iterator<Product> reverseIterator = productCollection.reverseIterator();
    while (reverseIterator.hasNext()) {
      System.out.println(reverseIterator.next());
    }
  }
}
```

```
Product [number=A238, name=Iphone 8, price=425.0, available=true]
Product [number=A236, name=Iphone 9, price=650.0, available=true]
Product [number=A235, name=Iphone 11, price=1050.0, available=false]
Product [number=A234, name=Iphone 10, price=850.0, available=true]
```

Writing your own iterator with a filter

```
public class FilterIterator<T> implements Iterator<T>{
  private final List<T> list;
  private int position;
  private Predicate<T> predicate;

  public FilterIterator(List<T> list, Predicate<T> predicate) {
    this.list = list;
    this.predicate=predicate;
    this.position = 0;
  }

  public Iterator<T> iterator() {
    return this;
  }

  @Override
  public boolean hasNext() {
    int tempPosition = position;
    while (tempPosition < list.size()) {
      T nextElement = list.get(tempPosition);
      if (predicate.test(nextElement)) {
        return true;
      }
      else {
        tempPosition++;
      }
    }
    return false;
  }
```

Pass a predicate

See if there is another element in the list where the predicate is true

Writing your own iterator with a filter

```
@Override
public T next() {
  int tempPosition = position;
  while (tempPosition < list.size()) {
    T nextElement = list.get(tempPosition);
    if (predicate.test(nextElement)) {
      position=tempPosition+1;
      return nextElement;
    }
    else {
      tempPosition++;
    }
  }
  return null;
}

@Override
public void remove() {
  throw new UnsupportedOperationException();
}
}
```

Find the next element in the list where the predicate is true

Not supported

Using your own filter iterator

```
public class ProductCollection {
  private List<Product> products = new ArrayList<>();

  public void addProduct(Product product){
    products.add(product);
  }

  public Iterator<Product> reverseIterator(){
    return new ReverseIterator<Product>(products);
  }

  public Iterator<Product> filterIterator(Predicate<Product> predicate){
    return new FilterIterator<Product>(products, predicate);
  }
}
```

Factory method creates the iterator

```
public class Product {
  private String number;
  private String name;
  private double price;
  private boolean available;
  ...
}
```

Using your own filter iterator

```
public class Application {

  public static void main(String[] args) {
    ProductCollection productCollection = new ProductCollection();
    productCollection.addProduct(new Product("A234", "Iphone 10", 850.0, true));
    productCollection.addProduct(new Product("A235", "Iphone 11", 1050.0, false));
    productCollection.addProduct(new Product("A236", "Iphone 9", 650.0, true));
    productCollection.addProduct(new Product("A238", "Iphone 8", 425.0, true));

    System.out.println("Available products:");
    Predicate<Product> availablepredicate = p -> p.isAvailable();
    Iterator<Product> filterIterator = productCollection.filterIterator(availablepredicate);
    while (filterIterator.hasNext()) {
      System.out.println(filterIterator.next());
    }
  }
}
```

```
Available products:
Product [number=A234, name=Iphone 10, price=850.0, available=true]
Product [number=A236, name=Iphone 9, price=650.0, available=true]
Product [number=A238, name=Iphone 8, price=425.0, available=true]
```

Using your own filter iterator

```
public class Application {

  public static void main(String[] args) {
    ProductCollection productCollection = new ProductCollection();
    productCollection.addProduct(new Product("A234", "Iphone 10", 850.0, true));
    productCollection.addProduct(new Product("A235", "Iphone 11", 1050.0, false));
    productCollection.addProduct(new Product("A236", "Iphone 9", 650.0, true));
    productCollection.addProduct(new Product("A238", "Iphone 8", 425.0, true));

    System.out.println("Products with price > 800:");
    Predicate<Product> pricepredicate = p -> p.getPrice() > 800;
    Iterator<Product> filterIterator = productCollection.filterIterator(pricepredicate);
    while (filterIterator.hasNext()) {
      System.out.println(filterIterator.next());
    }
  }
}
```

```
Products with price > 800:
Product [number=A234, name=Iphone 10, price=850.0, available=true]
Product [number=A235, name=Iphone 11, price=1050.0, available=false]
```

Using your own filter iterator

```
public class Application {

  public static void main(String[] args) {
    ProductCollection productCollection = new ProductCollection();
    productCollection.addProduct(new Product("A234", "Iphone 10", 850.0, true));
    productCollection.addProduct(new Product("A235", "Iphone 11", 1050.0, false));
    productCollection.addProduct(new Product("A236", "Iphone 9", 650.0, true));
    productCollection.addProduct(new Product("A238", "Iphone 8", 425.0, true));

    System.out.println("Available products with price > 800:");
    Predicate<Product> availablepricepredicate = p -> p.getPrice() > 800 && p.isAvailable();
    filterIterator = productCollection.filterIterator(availablepricepredicate);
    while (filterIterator.hasNext()) {
      System.out.println(filterIterator.next());
    }
  }
}
```

```
Available products with price > 800:
Product [number=A234, name=Iphone 10, price=850.0, available=true]
```

Streams

```
public class ApplicationFilter {

  public static void main(String[] args) {
    List<Product> products = new ArrayList<>();
    products.add(new Product("A234", "Iphone 10", 850.0, true));
    products.add(new Product("A235", "Iphone 11", 1050.0, false));
    products.add(new Product("A236", "Iphone 9", 650.0, true));
    products.add(new Product("A238", "Iphone 8", 425.0, true));

    System.out.println("Available products:");
    List<Product> availableProducts = products.stream()
      .filter(p -> p.isAvailable())
      .collect(Collectors.toList());
    availableProducts.forEach(p -> System.out.println(p));

    System.out.println("Products with price > 800:");
    List<Product> expensiveProducts = products.stream()
      .filter(p -> p.getPrice() > 800)
      .collect(Collectors.toList());
    expensiveProducts.forEach(p -> System.out.println(p));

    System.out.println("Available products with price > 800:");
    List<Product> availableExpensiveProducts = products.stream()
      .filter(p ->  p.isAvailable())
      .filter(p -> p.getPrice() > 800)
      .collect(Collectors.toList());

    availableExpensiveProducts.forEach(p -> System.out.println(p));
  }
}
```

Main point

- The iterator pattern separates the iteration functionality from the collection so that the client is unaware of the structure of the collection.
- When one grows in consciousness, one spontaneously starts to live in harmony with all elements in creation without knowing all the details.