Overview of Java's Support for Polymorphism

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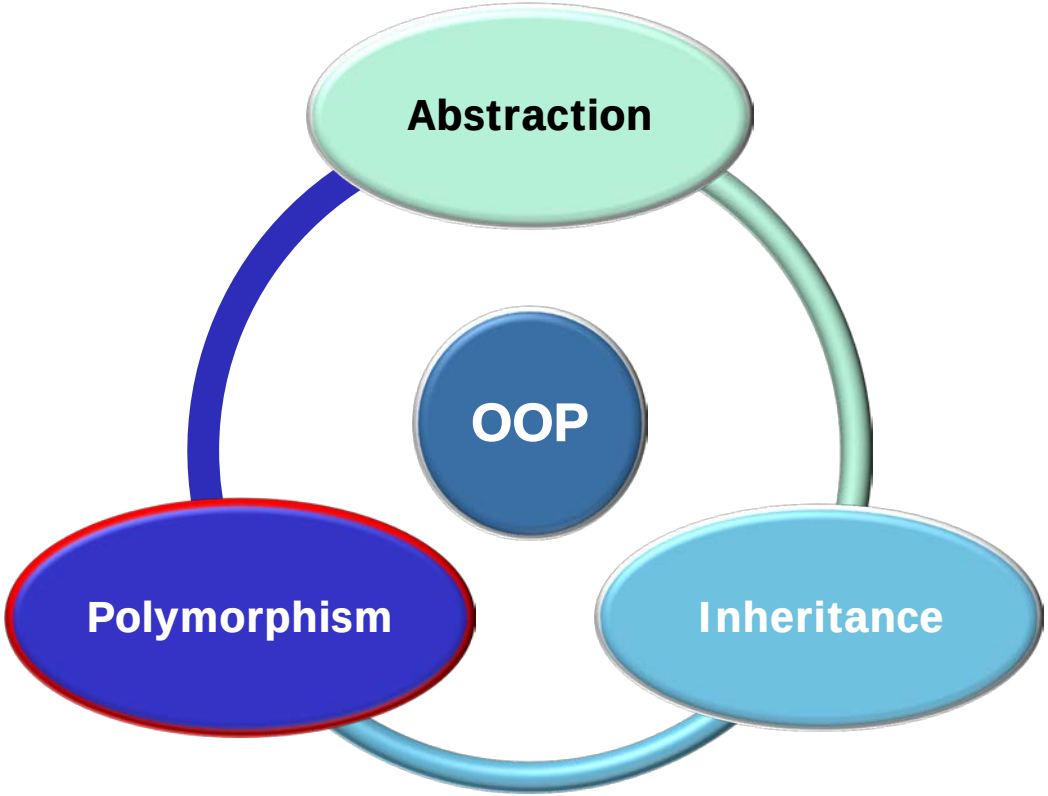
Learning Objectives in this Lesson

- Understand what polymorphism is & how it's supported in Java



Overview of Java's Support for Polymorphism

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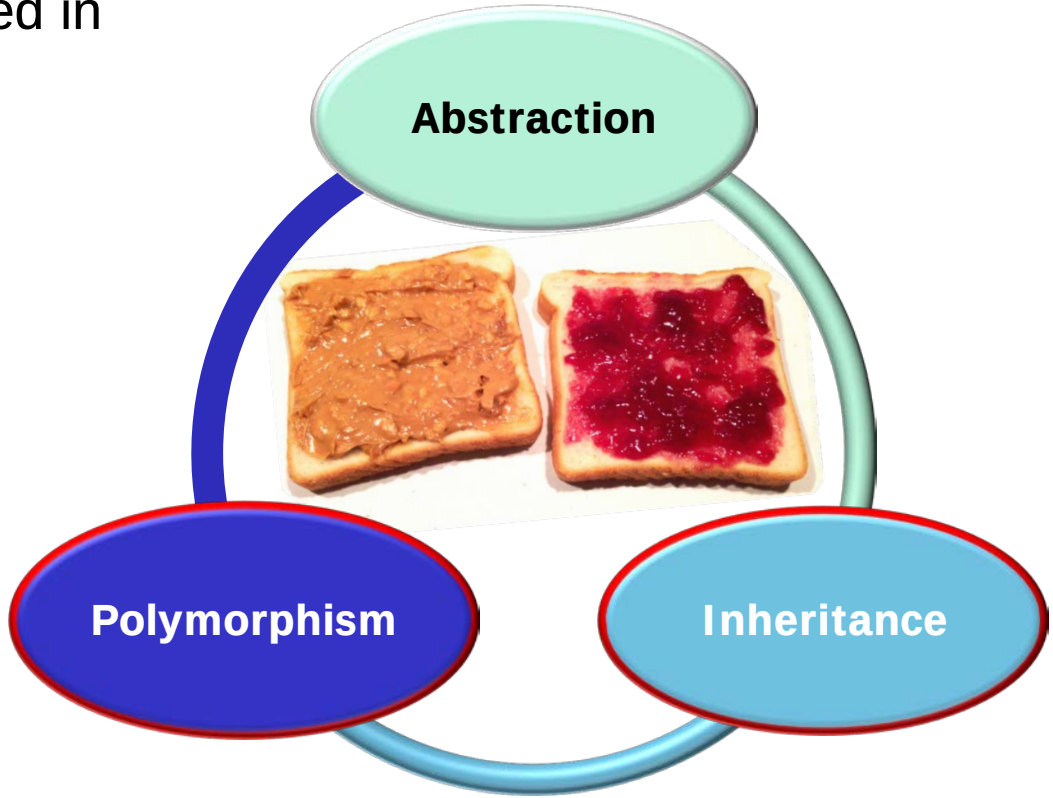
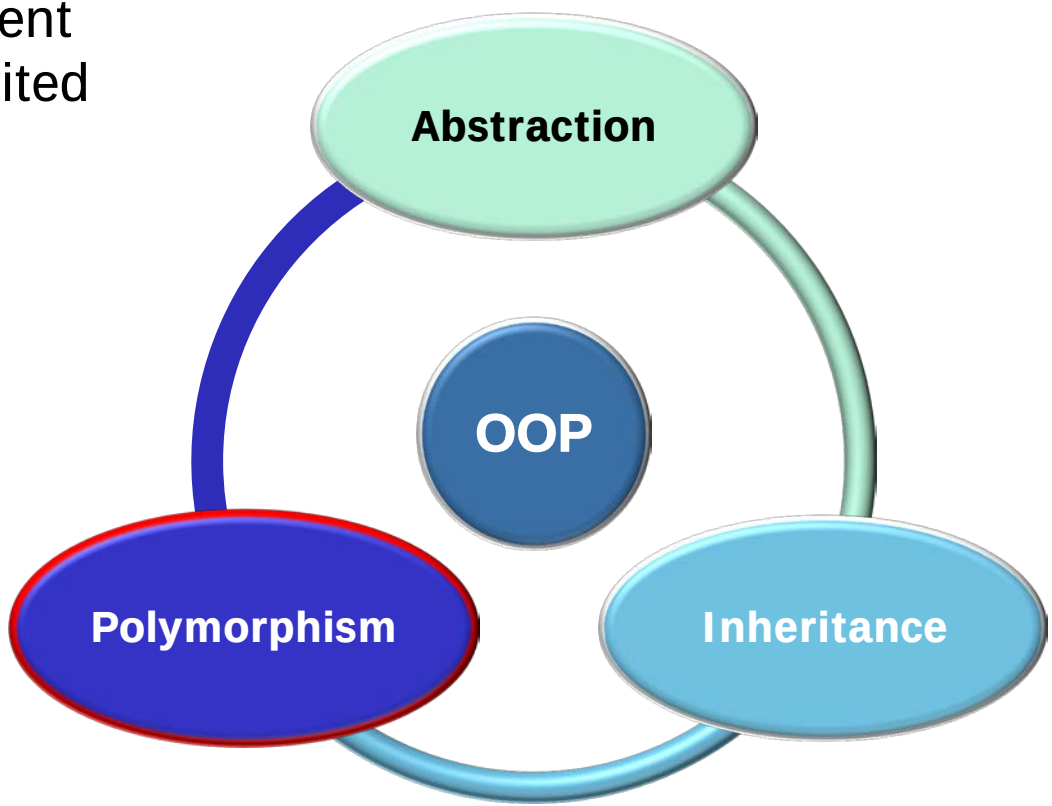
- Inheritance is nearly always used in conjunction with polymorphism



Overview of Java's Support for Polymorphism

- Polymorphism enables transparent customization of methods inherited from a super class



See en.wikipedia.org/wiki/Polymorphism_(computer_science)

Overview of Java's Support for Polymorphism

- Polymorphism & inheritance are essential to the "open/closed principle"

See en.wikipedia.org/wiki/Open/closed_principle

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- Polymorphism & inheritance are essential to the "open/closed principle"
  - "A class should be open for extension, but closed for modification"

See en.wikipedia.org/wiki/Open/closed_principle

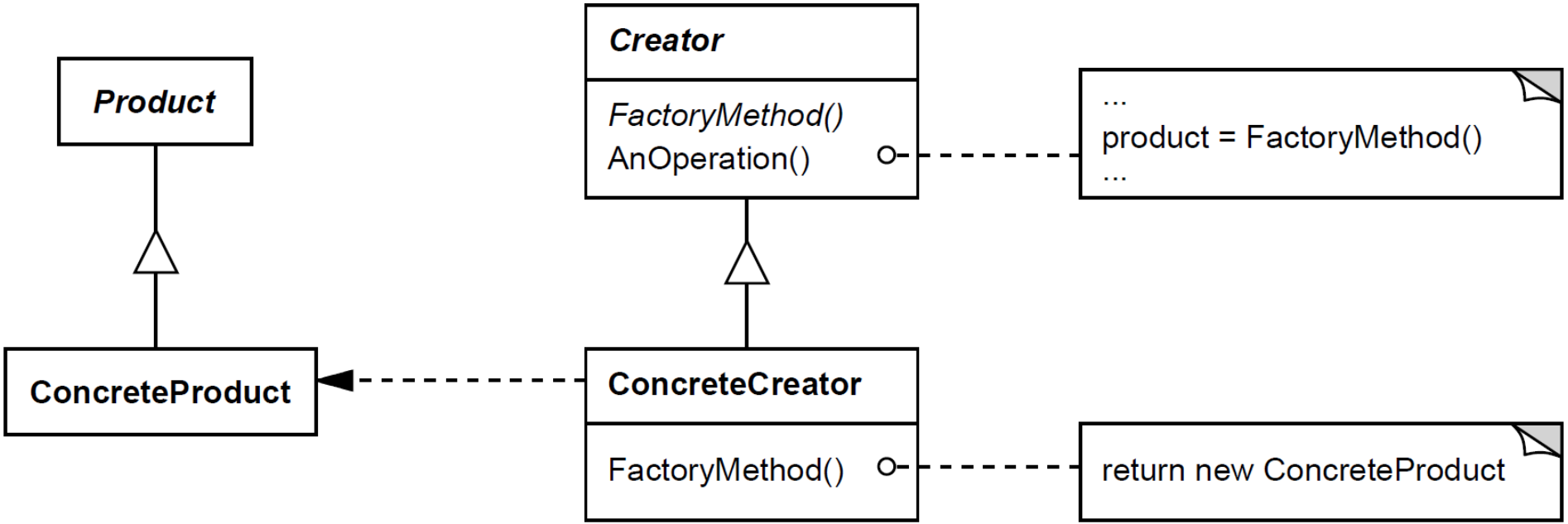
Overview of Java's Support for Polymorphism

- Polymorphism & inheritance are essential to the "open/closed principle"
  - "A class should be open for extension, but closed for modification"
  - Insulating clients of a class from modifications makes software more robust, flexible, & reusable

See www.dre.vanderbilt.edu/~schmidt/OCP.pdf

Overview of Java's Support for Polymorphism

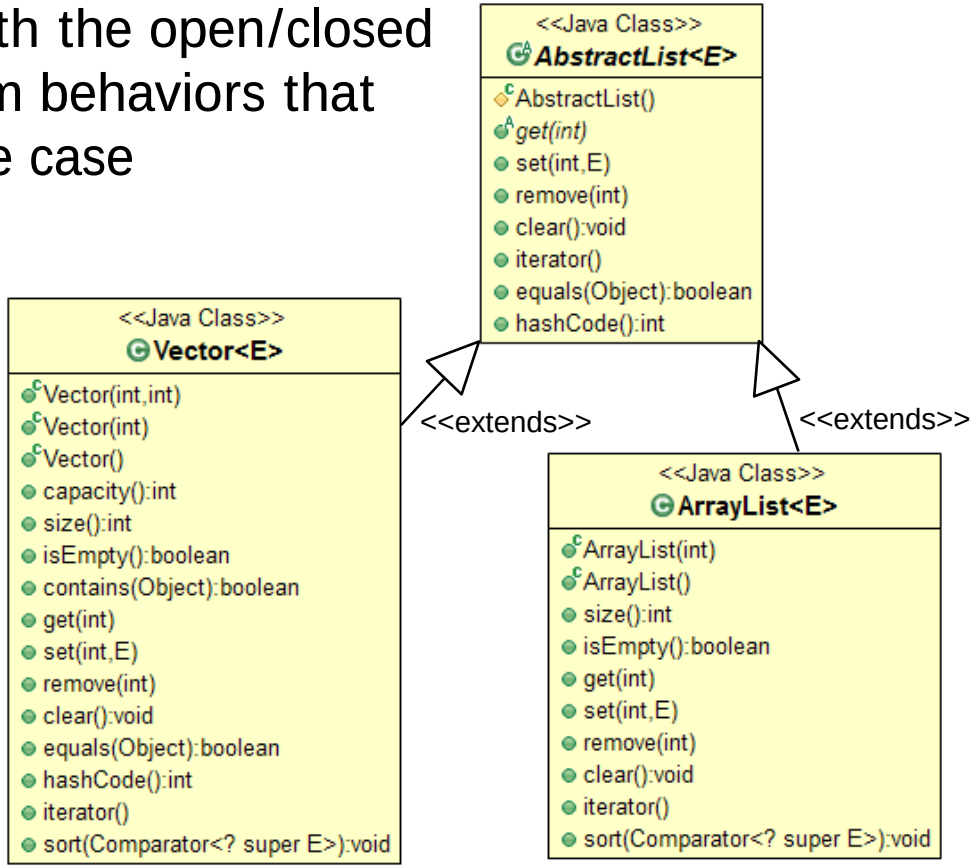
- The "open/closed principle" can be applied in conjunction with patterns to enable extensions *without* modifying existing classes or apps



See en.wikipedia.org/wiki/Factory_method_pattern

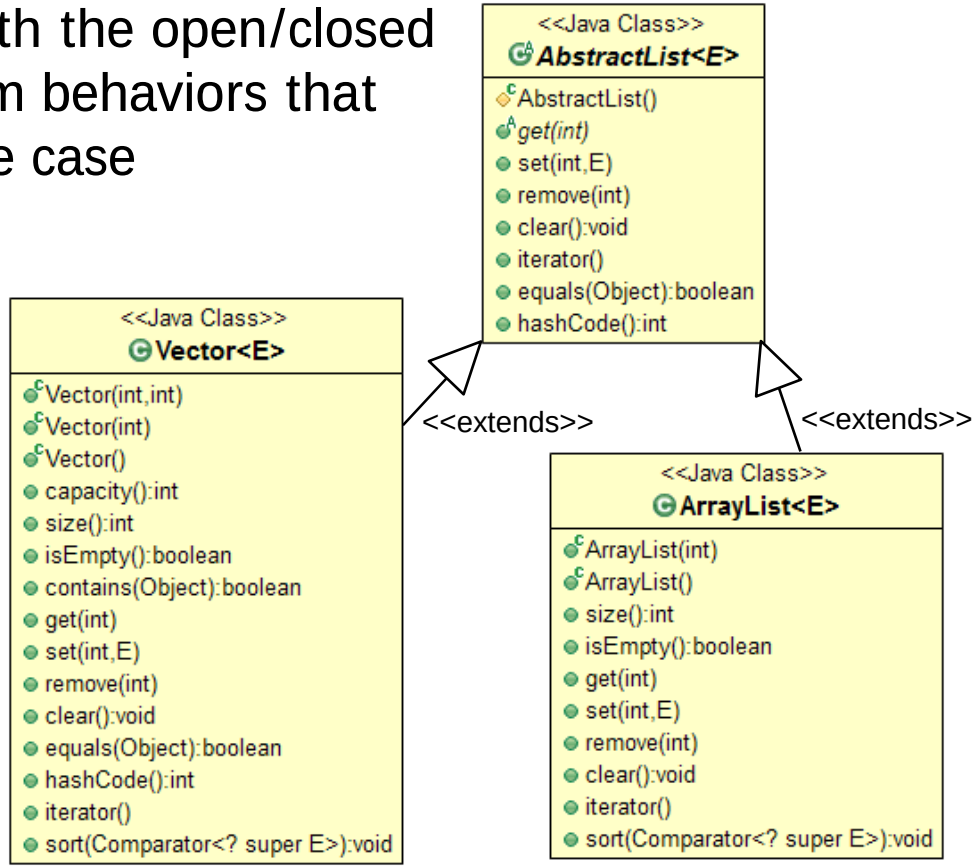
Overview of Java's Support for Polymorphism

- Subclasses defined in accordance with the open/closed principle can define their own custom behaviors that are more suitable for a particular use case



Overview of Java's Support for Polymorphism

- Subclasses defined in accordance with the open/closed principle can define their own custom behaviors that are more suitable for a particular use case
  - While still reusing structure & functionality from super class



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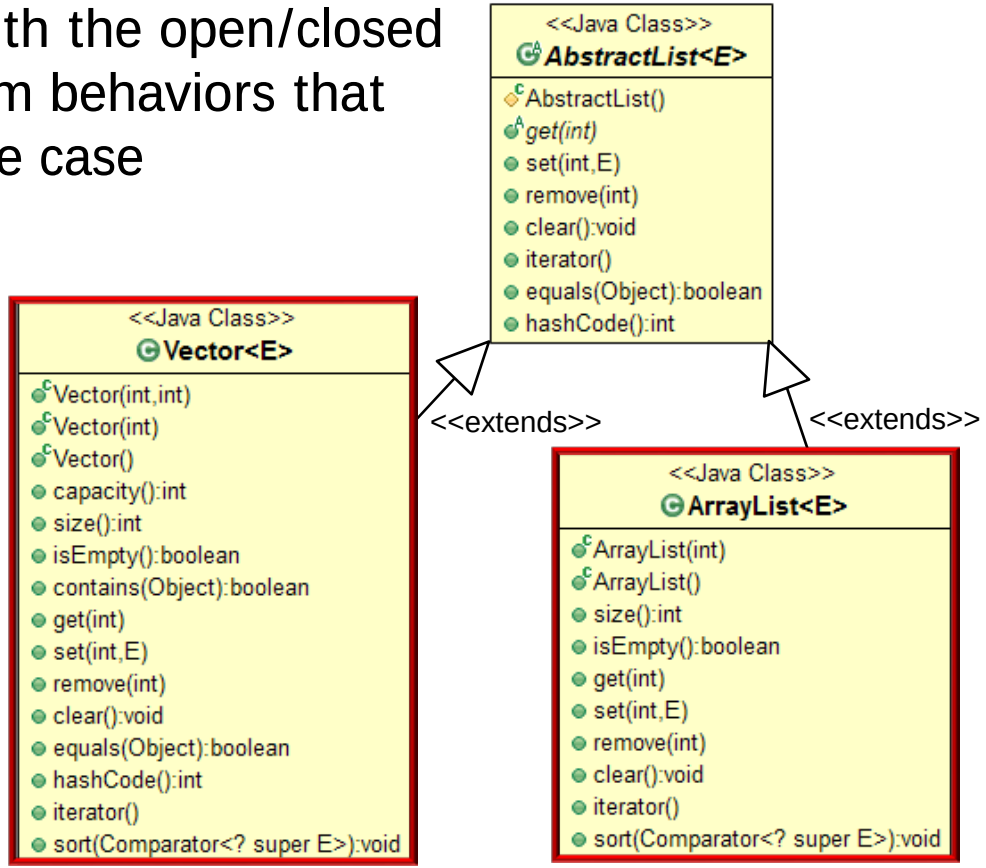
    - e.g., Vector & ArrayList both inherit AbstractList methods



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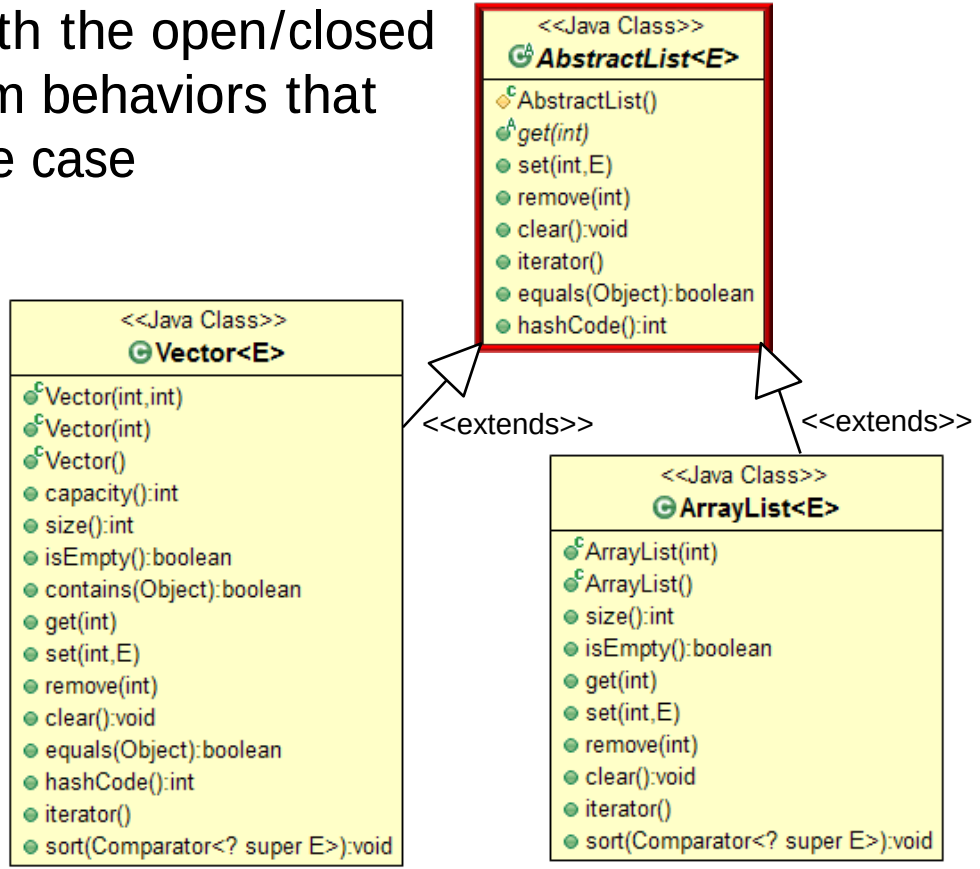

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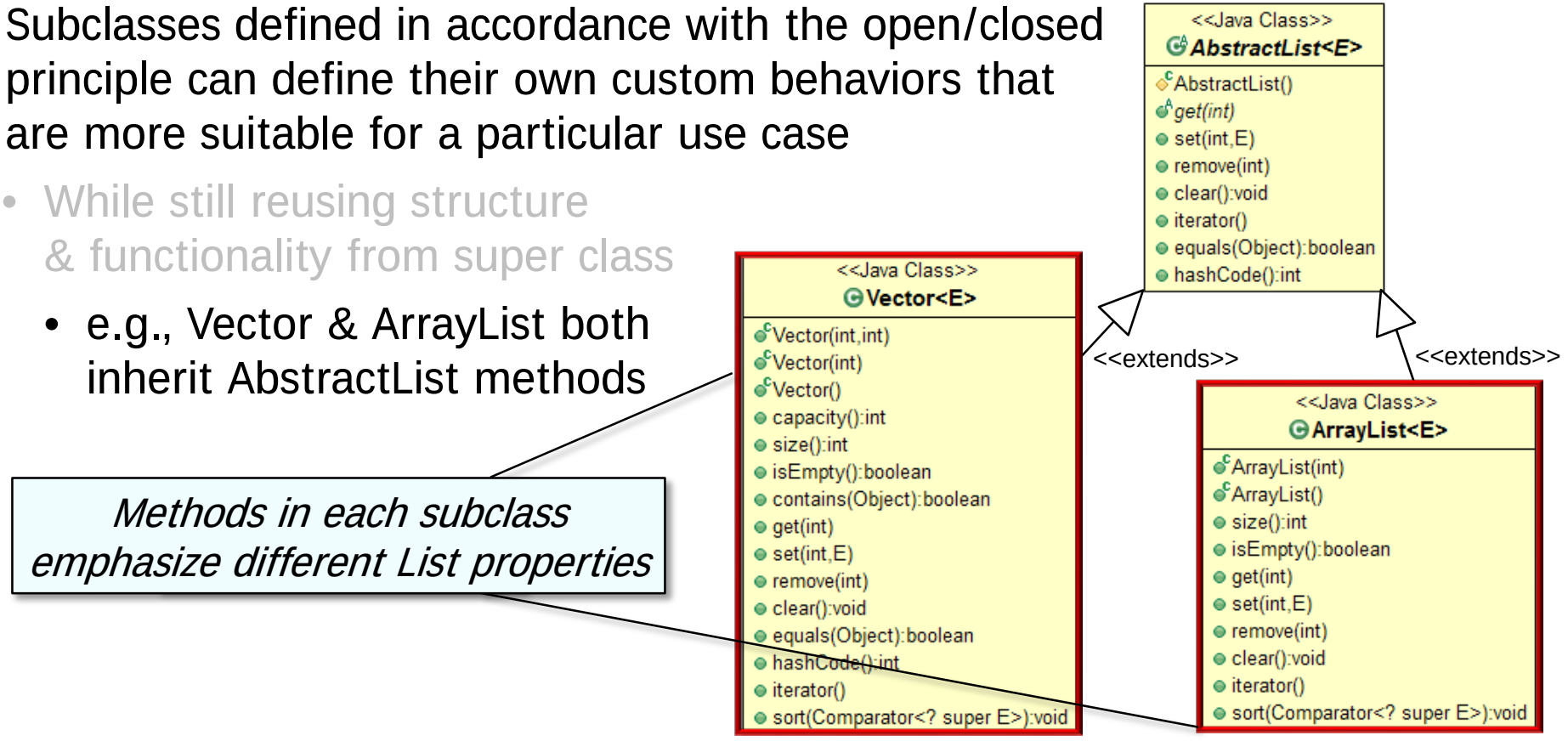
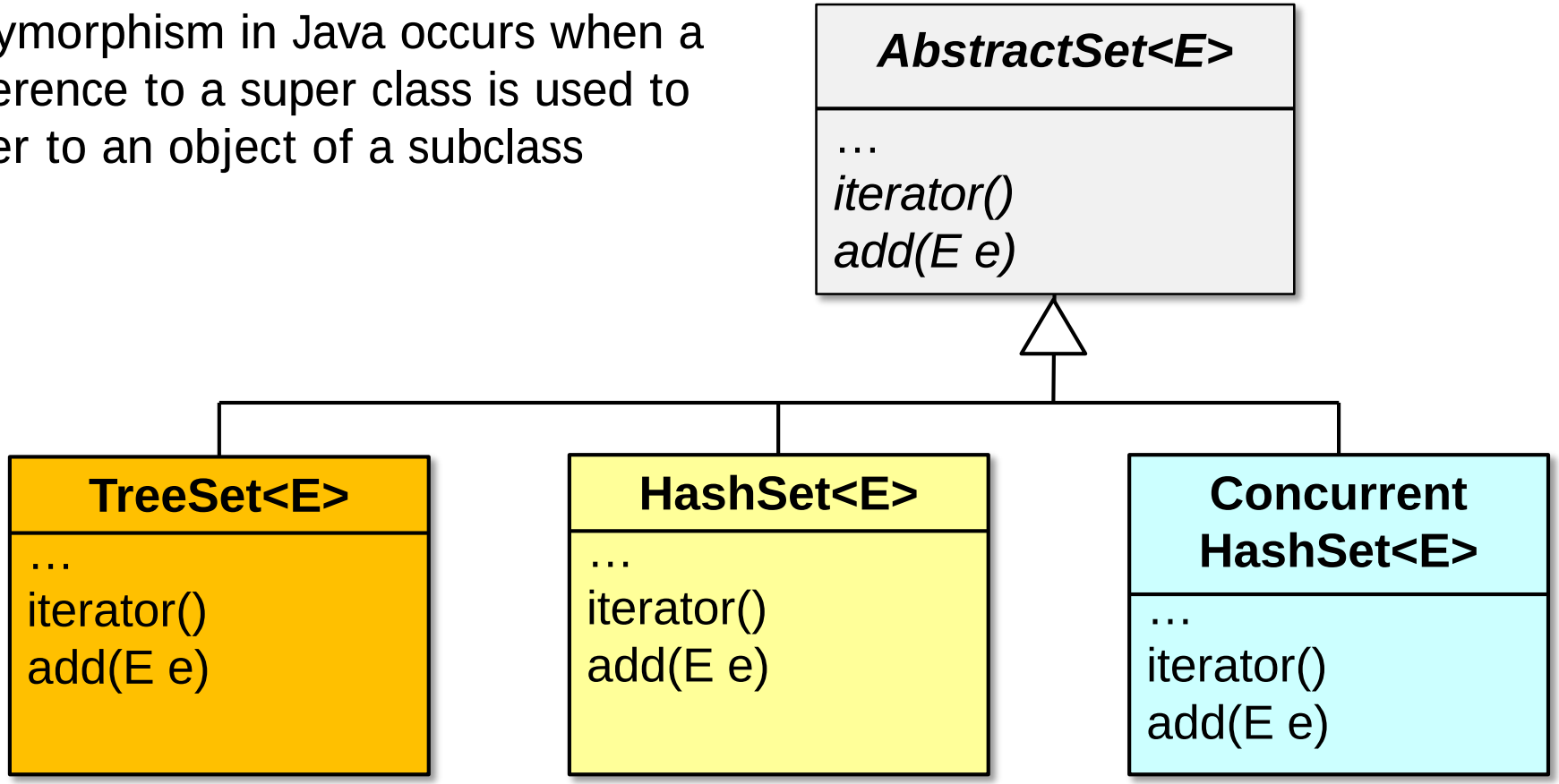


See beginnersbook.com/2013/12/difference-between-arraylist-and-vector-in-java

Method Overriding in Java Polymorphism

Method Overriding in Java Polymorphism

- Polymorphism in Java occurs when a reference to a super class is used to refer to an object of a subclass



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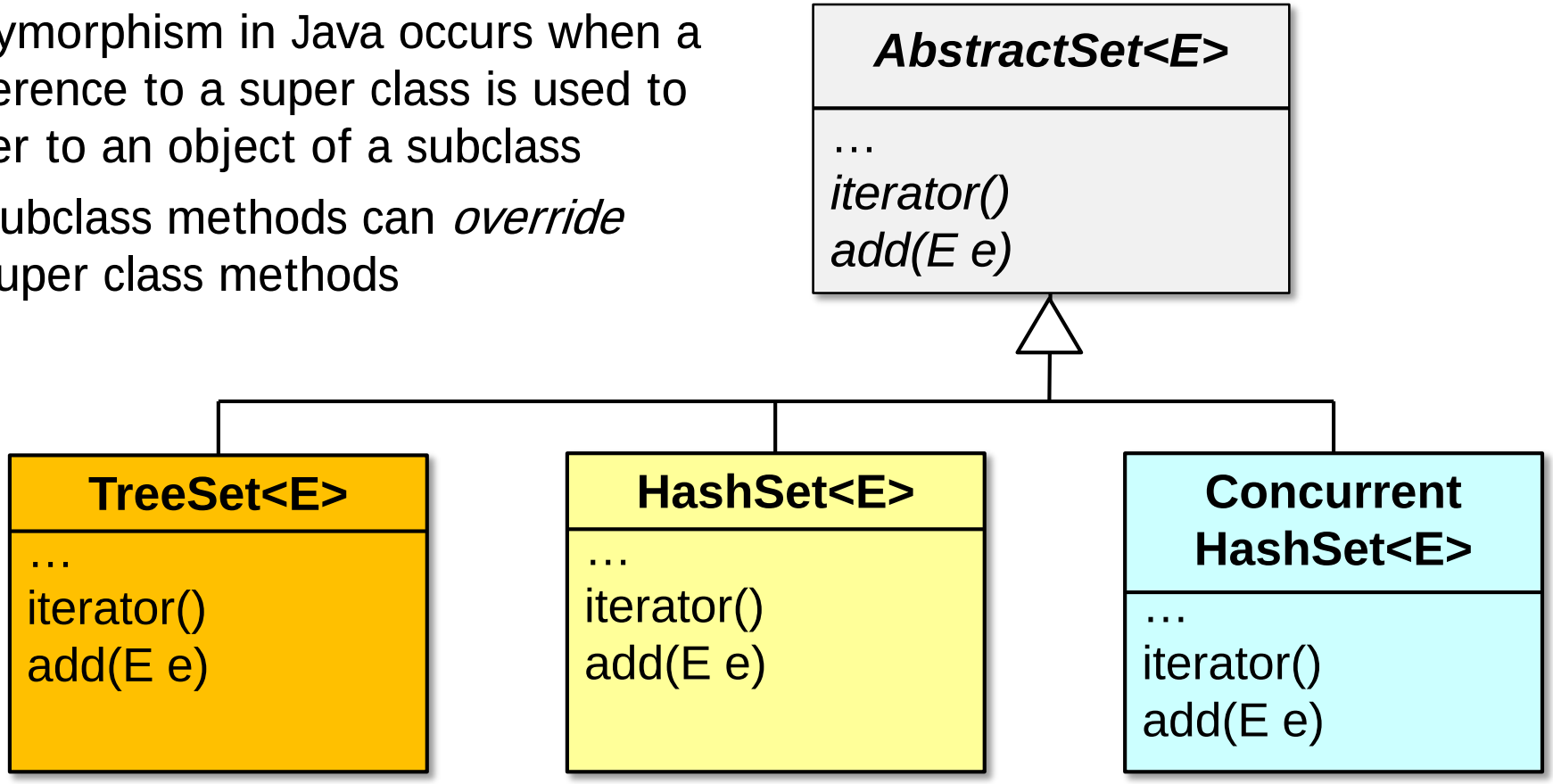
  - Subclass methods can *override* super class methods



Any non-final & non-static methods can be overridden

Method Overriding in Java Polymorphism

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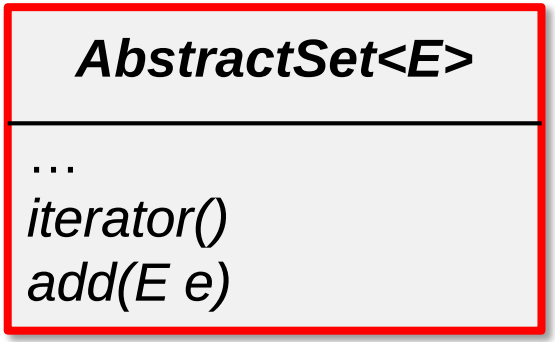

See docs.oracle.com/javase/8/docs/api/java/util/AbstractSet.html

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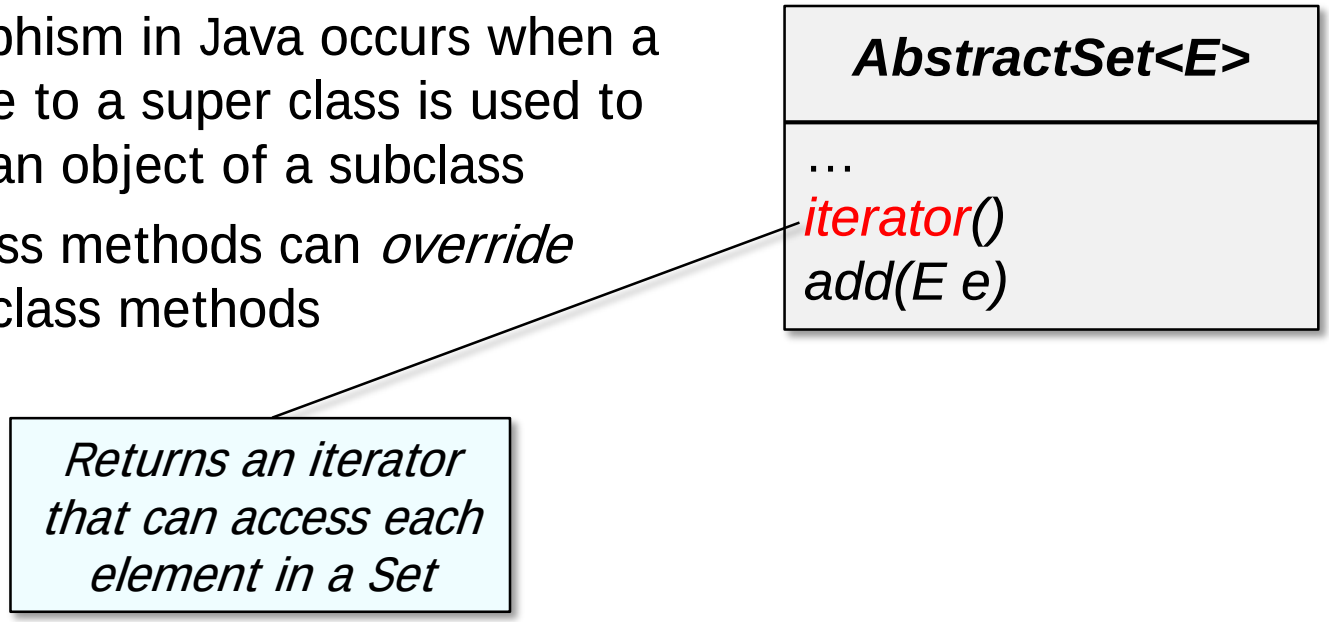

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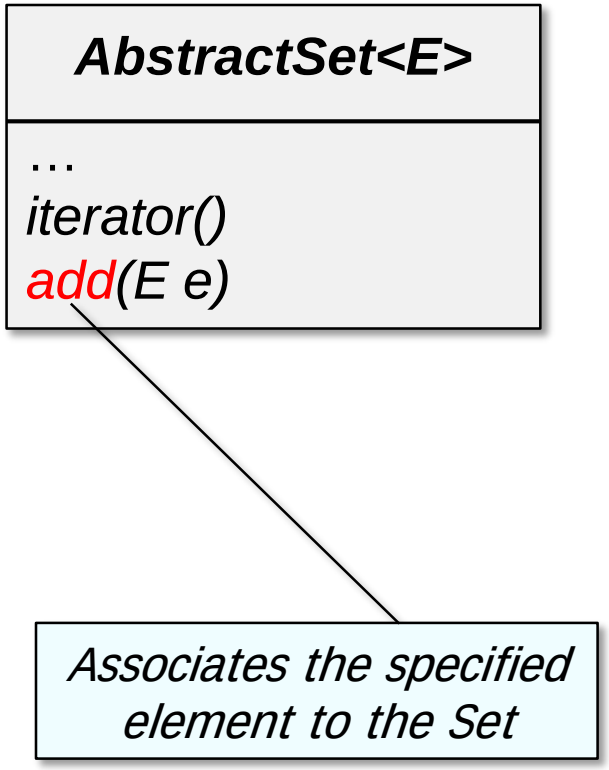

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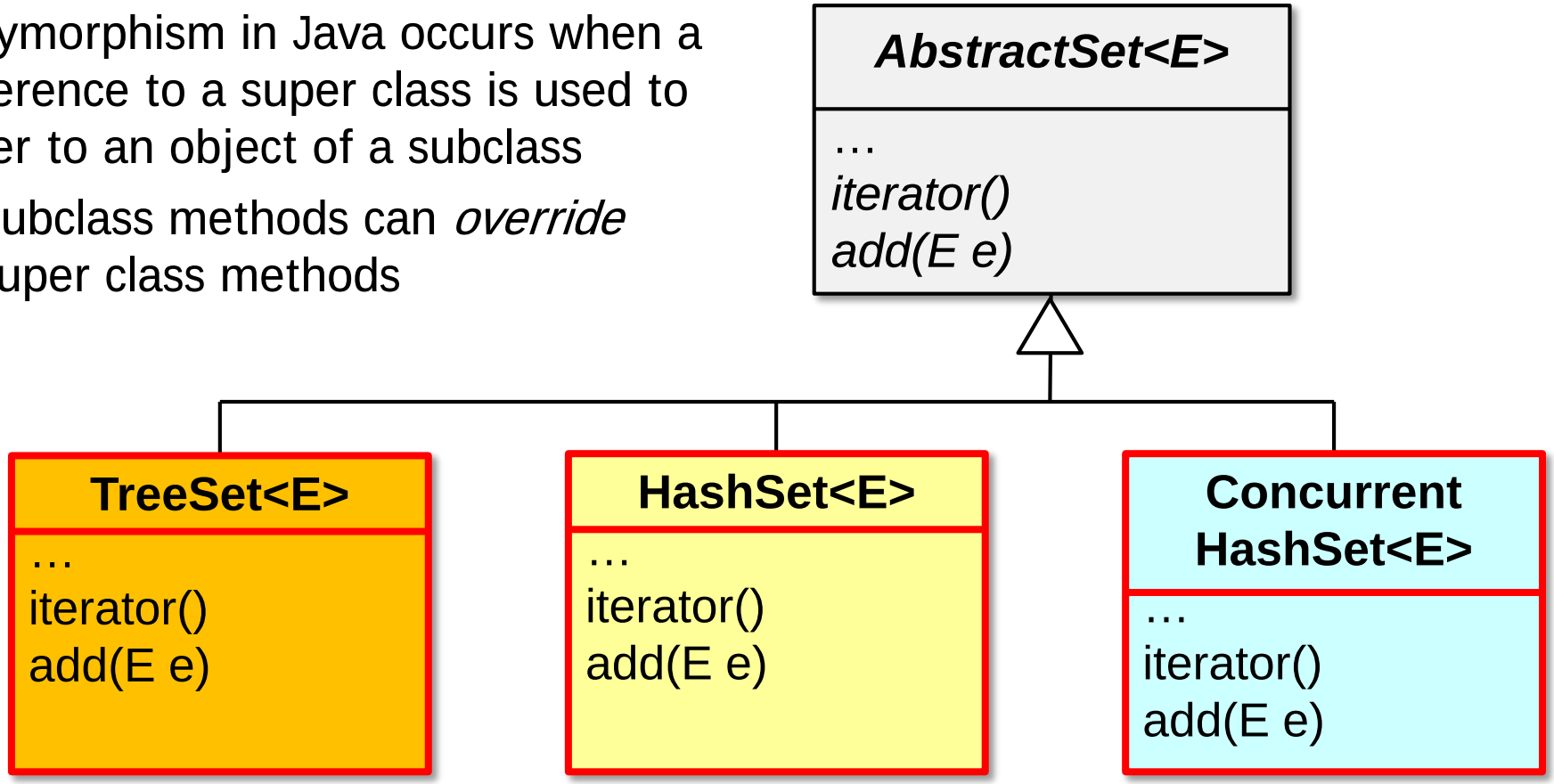

Subclasses of AbstractSet can override add(E e) & iterator() differently

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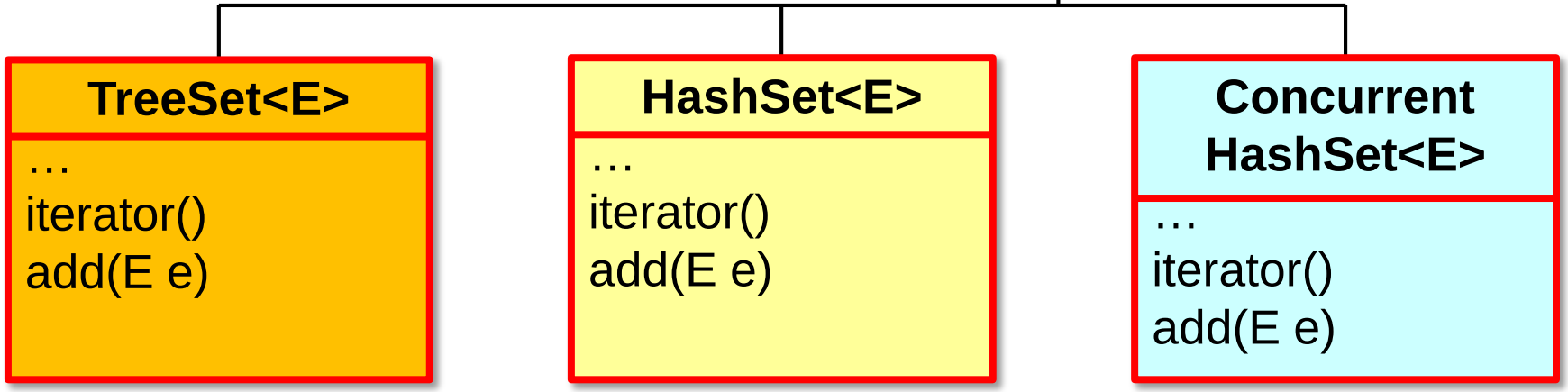

Subclasses of AbstractSet have different time & space tradeoffs

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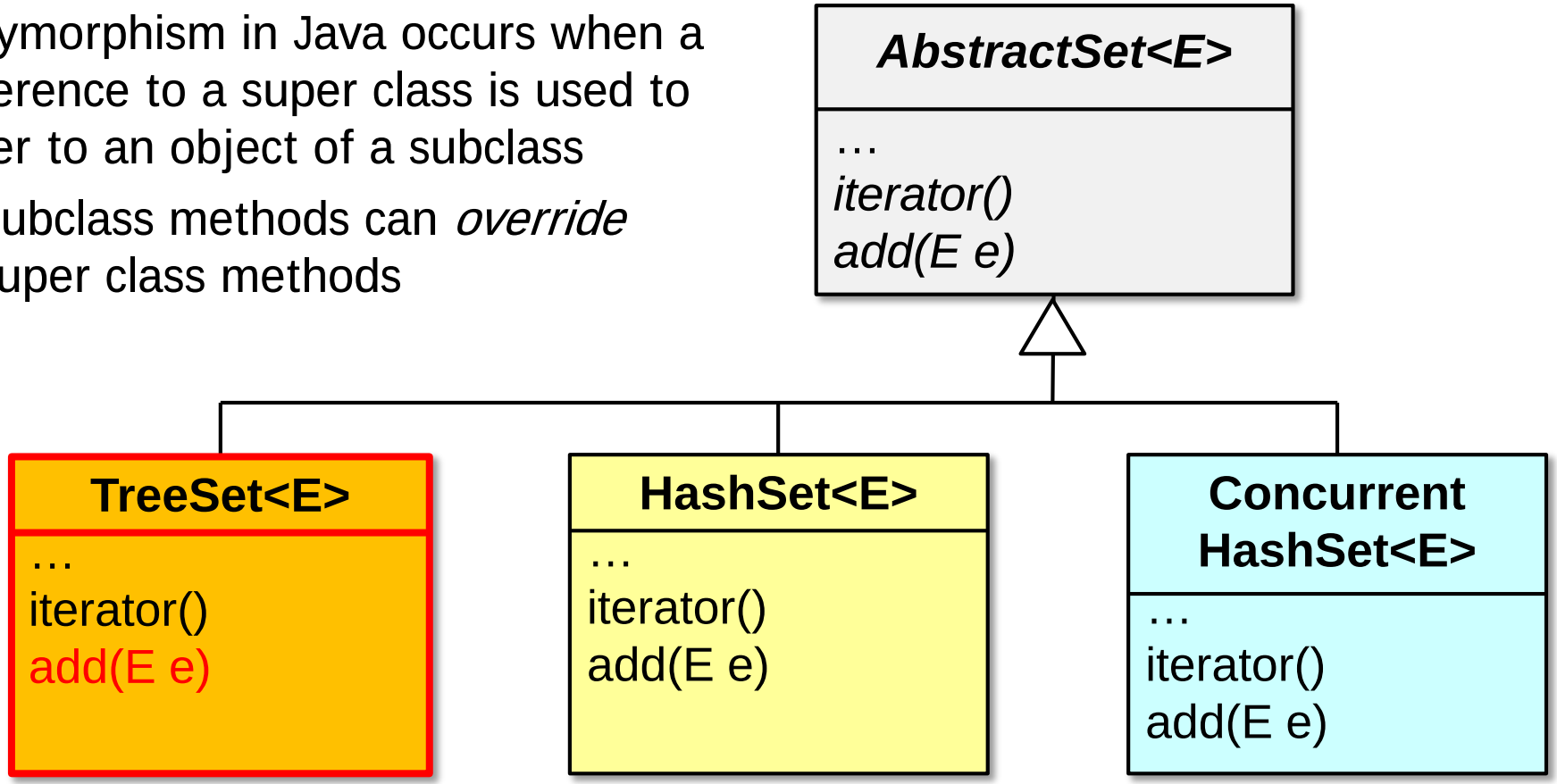

See docs.oracle.com/javase/8/docs/api/java/util/TreeSet.html

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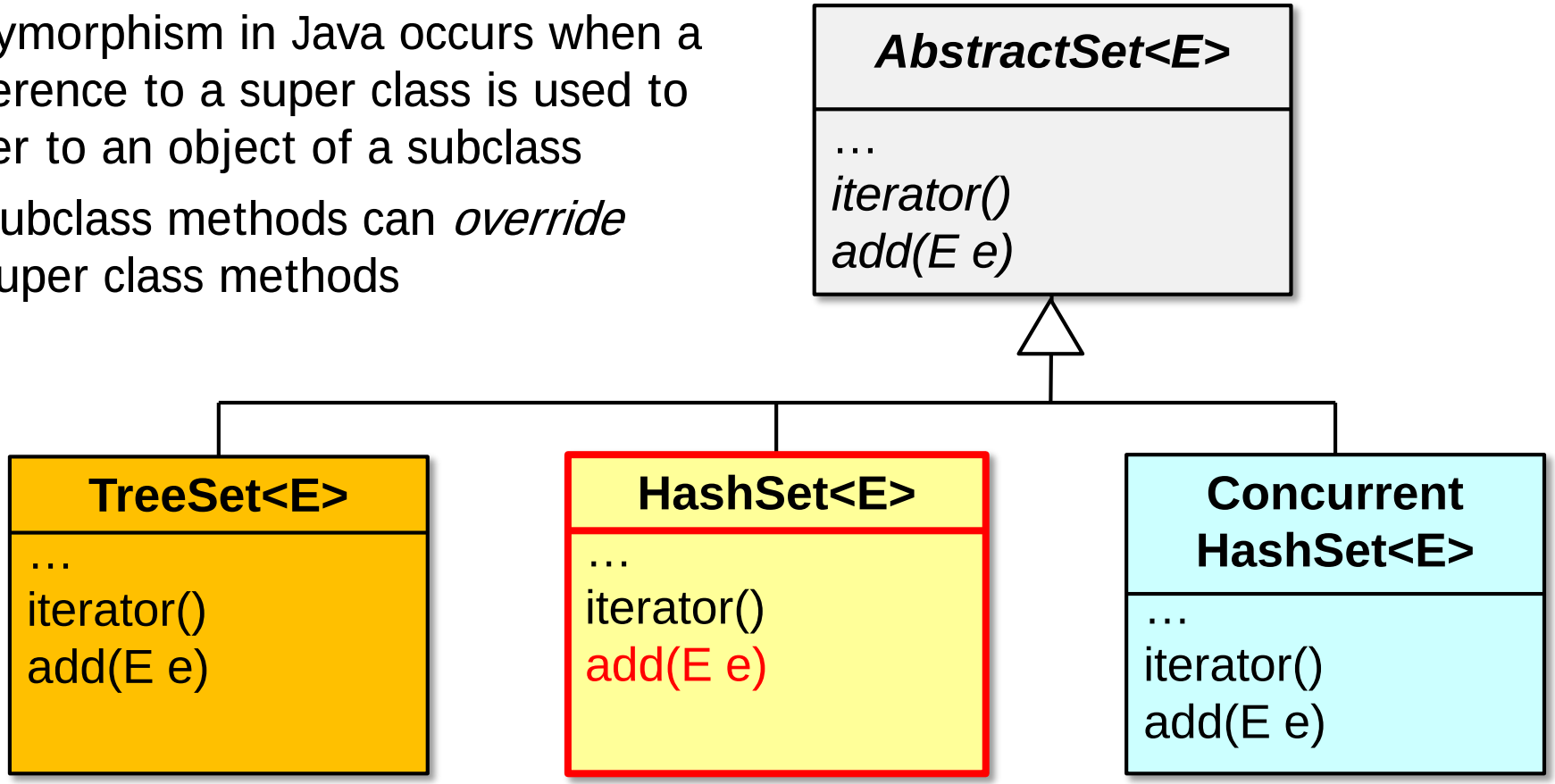

See docs.oracle.com/javase/8/docs/api/java/util/HashSet.html

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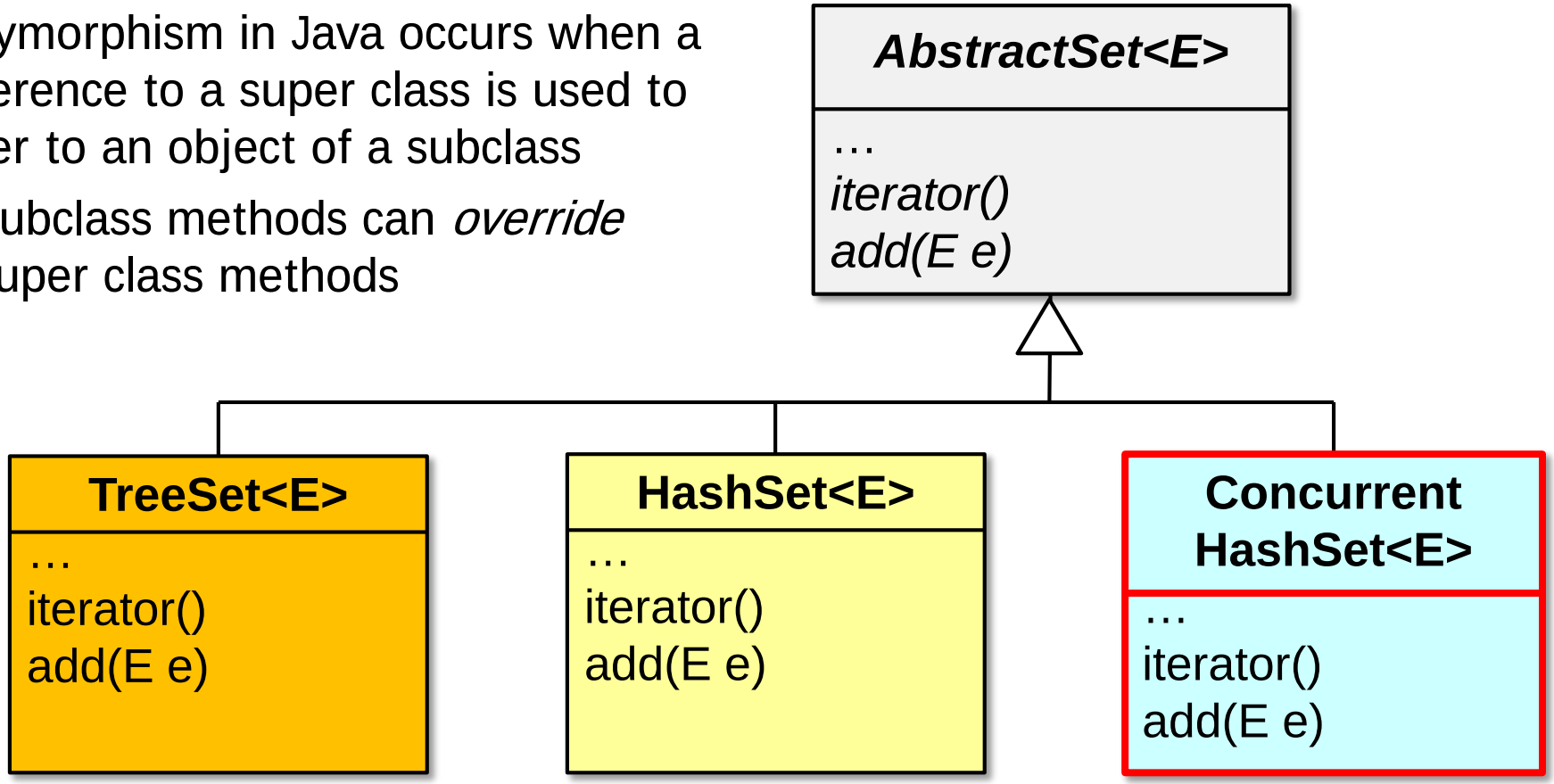
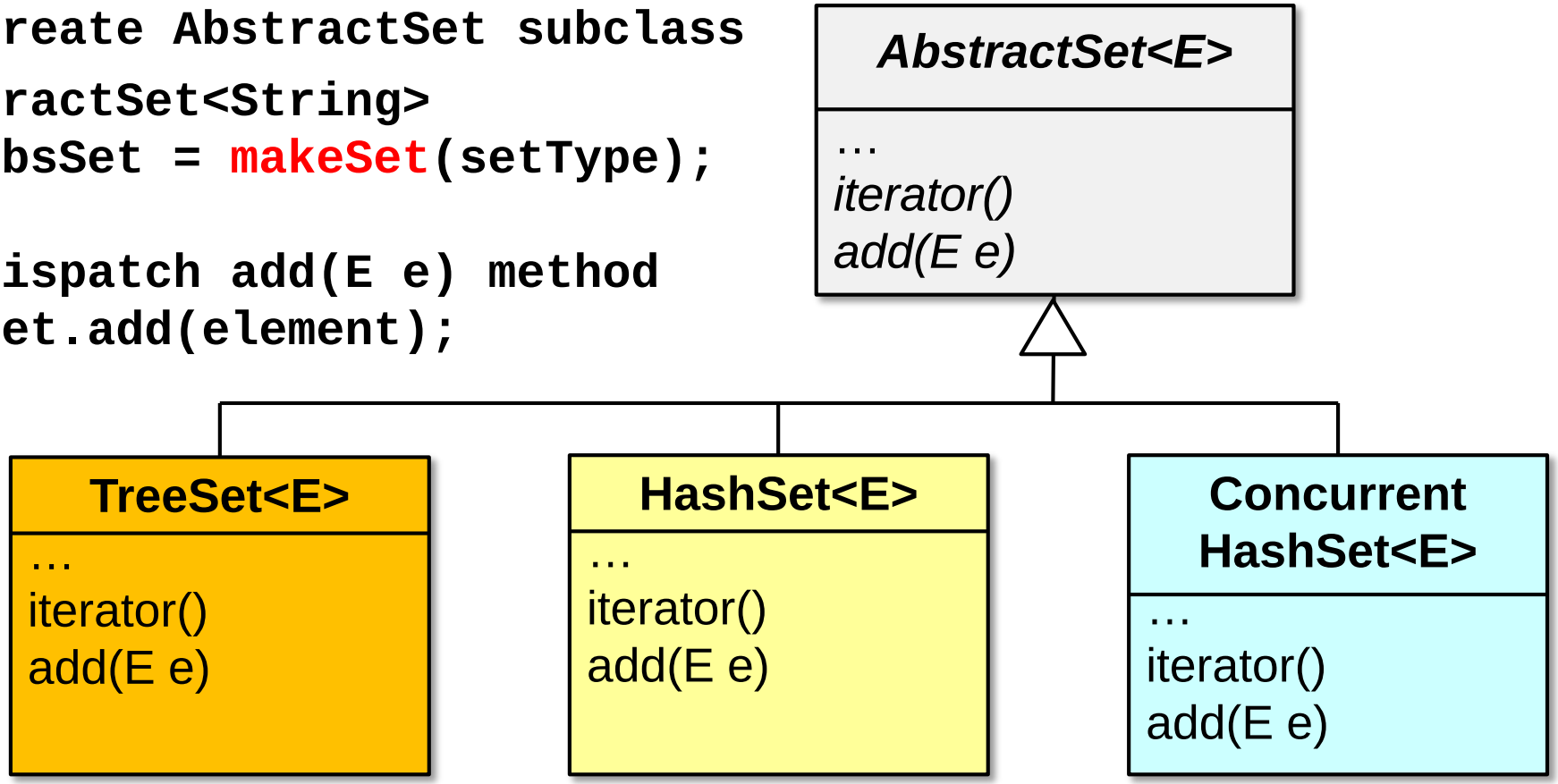


See Java8/ex19/src/main/java/utils/ConcurrentHashSet.java

Method Overriding in Java Polymorphism

```
// Create AbstractSet subclass
AbstractSet<String>
    absSet = makeSet(setType);
...
// Dispatch add(E e) method
absSet.add(element);
```



A factory method creates the appropriate concrete set subclass instance

Method Overriding in Java Polymorphism

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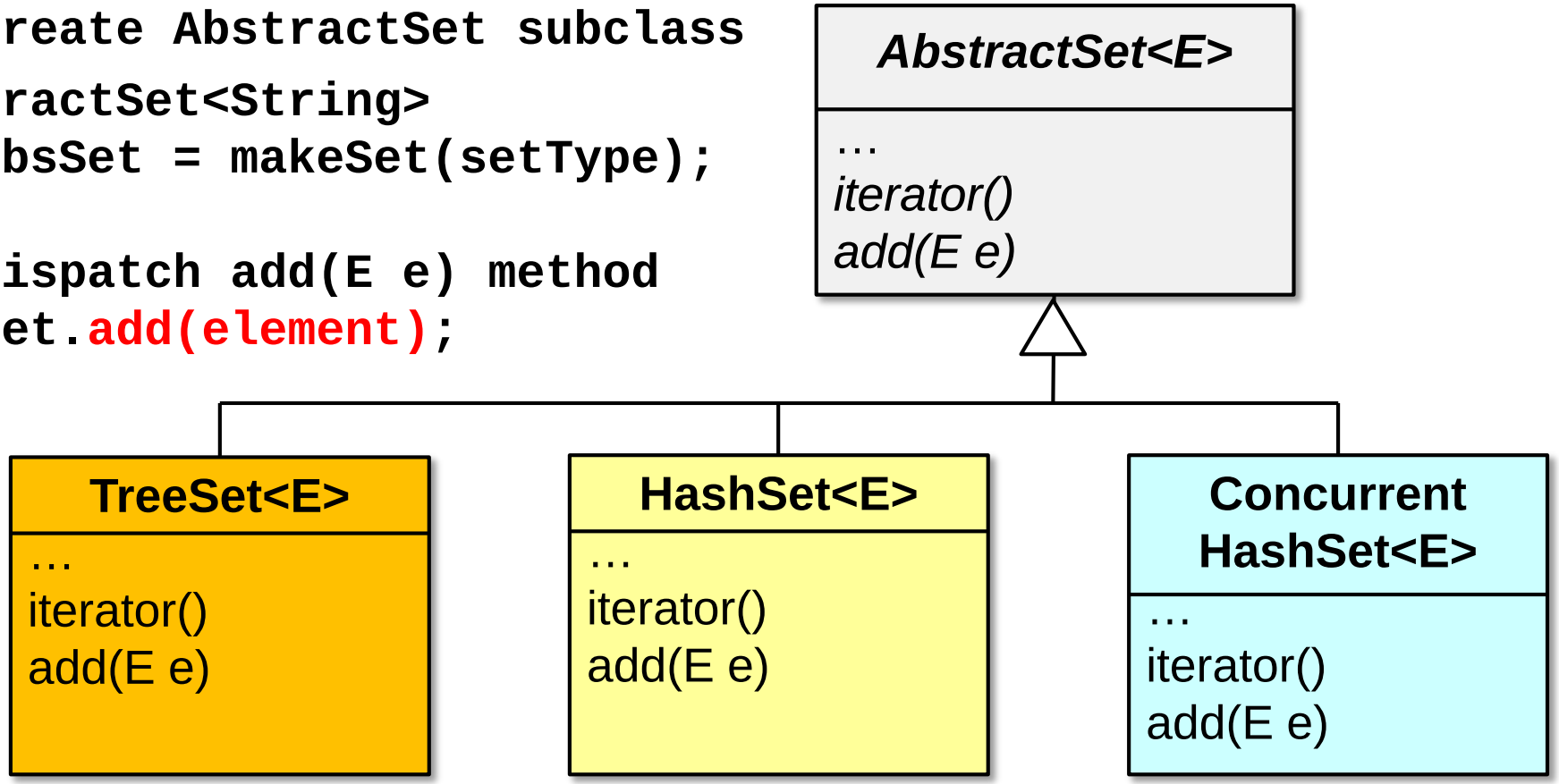

The appropriate method is dispatched at runtime based on the subclass object

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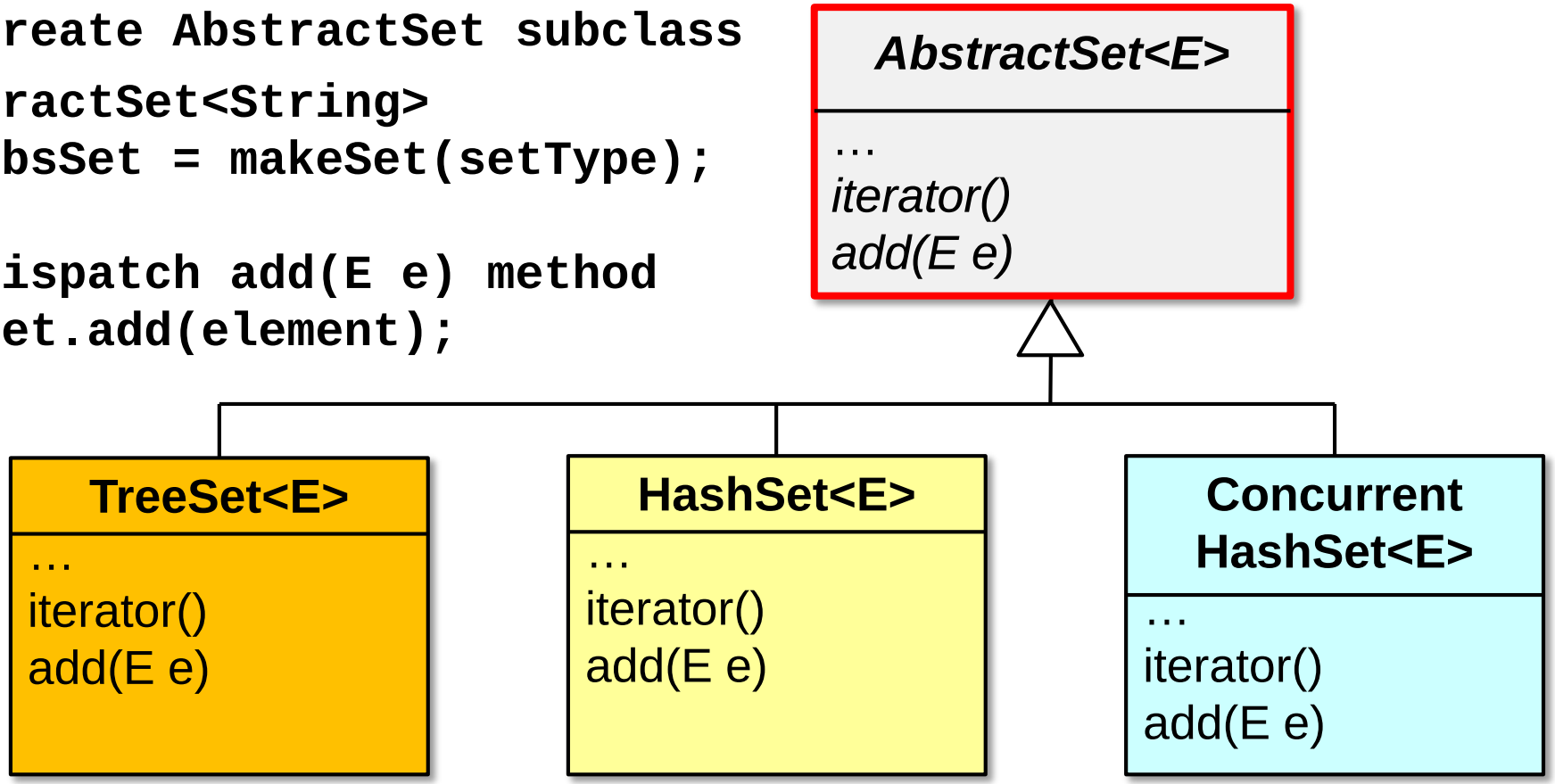

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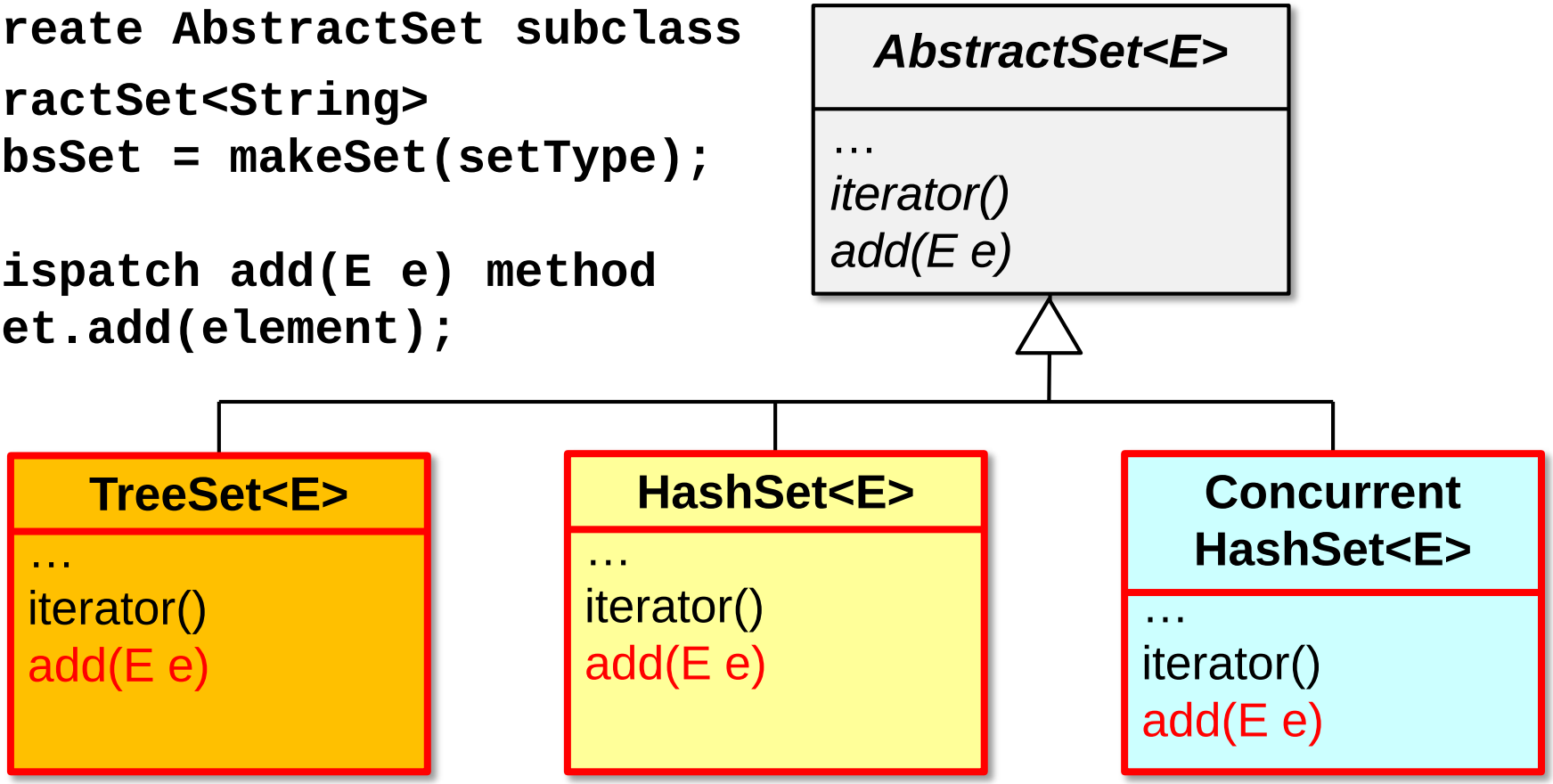

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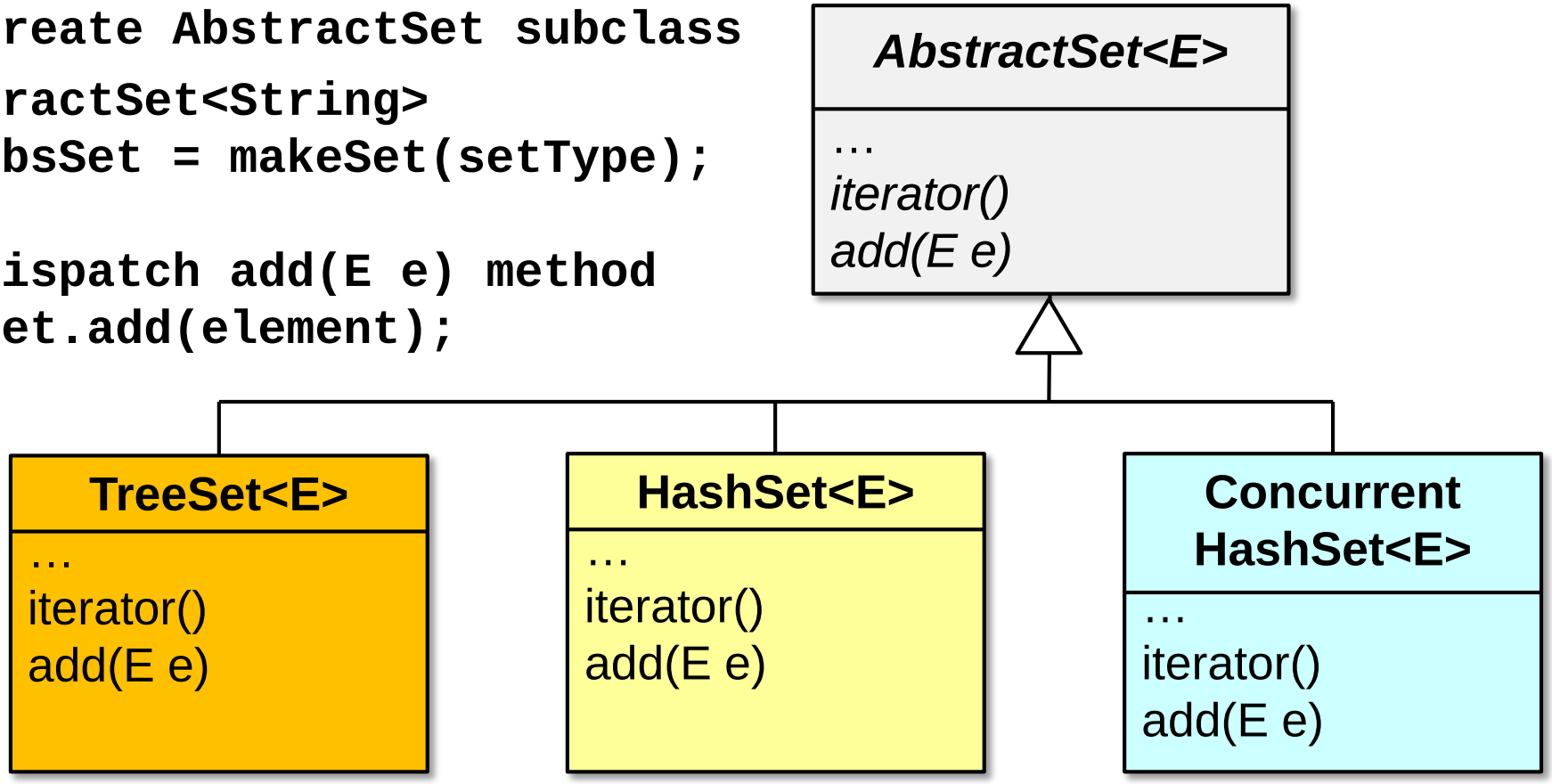

See en.wikipedia.org/wiki/Factory_method_pattern & en.wikipedia.org/wiki/Open/closed_principle

Example of Inheritance & Polymorphism in Java

Example of Inheritance & Polymorphism in Java

- The implementation of these methods is selected at run-time based on the object's type

```
static void main(String[] args) {
  SimpleAbstractSet<String> set =
    makeSet(...);

  set.put("I");
  set.put("am");
  set.put("Ironman");
  set.put("Ironman");

  for(Iterator<String> it =
                        set.iterator();
      it.hasNext();)
    System.out.println
      ("item = " + iter.next());
}
```

See github.com/douglascraigschmidt/CS891/tree/master/ex/DynamicBinding

Example of Inheritance & Polymorphism in Java

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Factory method creates a HashSet, TreeSet, or ConcurrentHashSet, etc.

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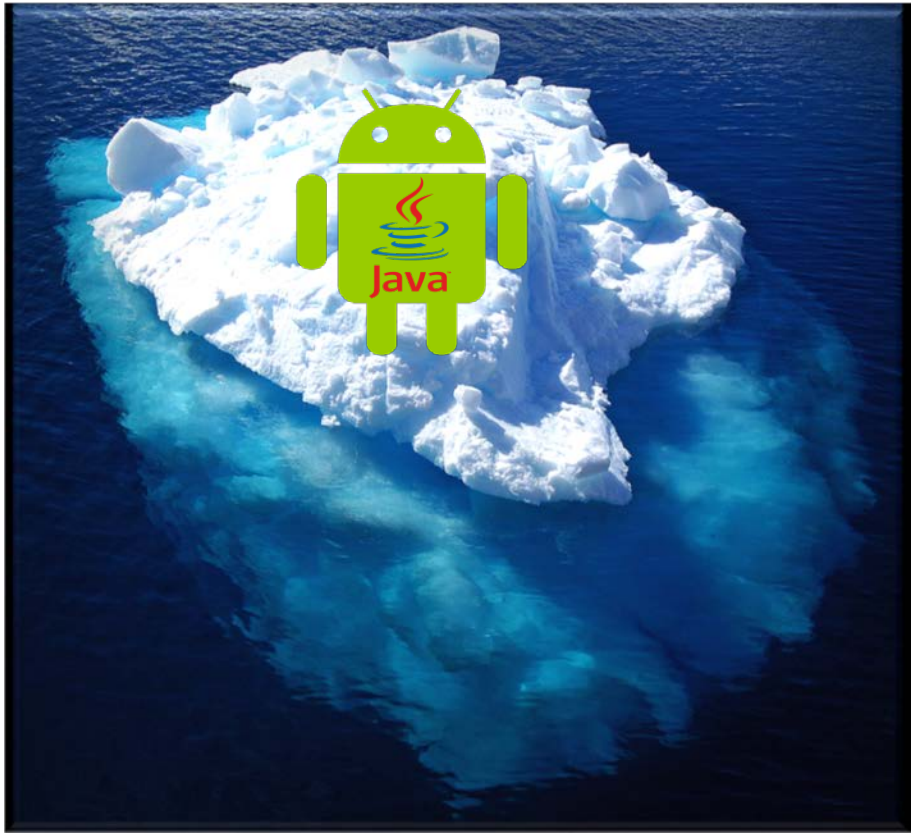
The put() method & iterator that are dispatched are based on the concrete type of the set

Implementing Dynamic & Static Dispatching in Java

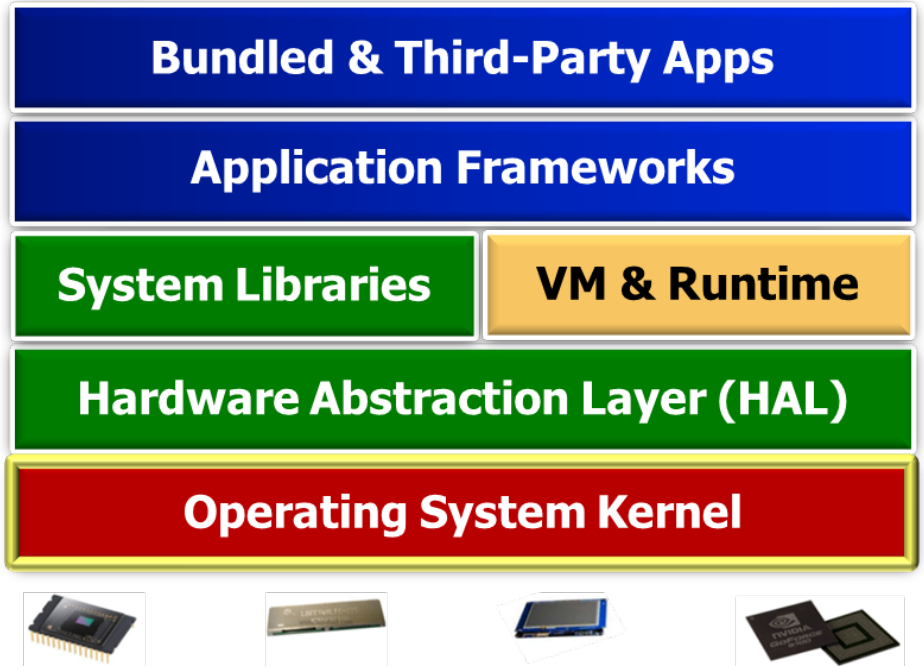
Implementing Dynamic Dispatching in Java

- You needn’t know how polymorphism is implemented to use it properly



Implementing Dynamic Dispatching in Java

- You needn't know how polymorphism is implemented to use it properly
  - Understanding how polymorphism works will help you become a "full stack developer"



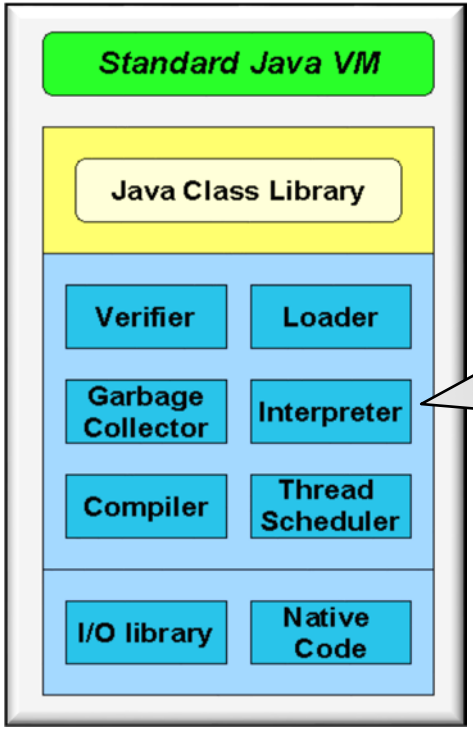
See www.laurencegellert.com/2012/08/what-is-a-full-stack-developer

Implementing Dynamic Dispatching in Java

- You needn't know how polymorphism is implemented to use it properly
  - Understanding how polymorphism works will help you become a "full stack developer"
  - Also helps you strike a balance between flexibility & efficiency

Implementing Dynamic Dispatching in Java

- Polymorphism is implemented by the Java compiler & Java Virtual Machine



invokevirtual

Operation

Invoke instance method; dispatch based on class

Format

```
invokevirtual
indexbyte1
indexbyte2
```

See docs.oracle.com/javase/specs/jvms/se7/html/jvms-6.html#jvms-6.5.invokevirtual

Implementing Dynamic Dispatching in Java

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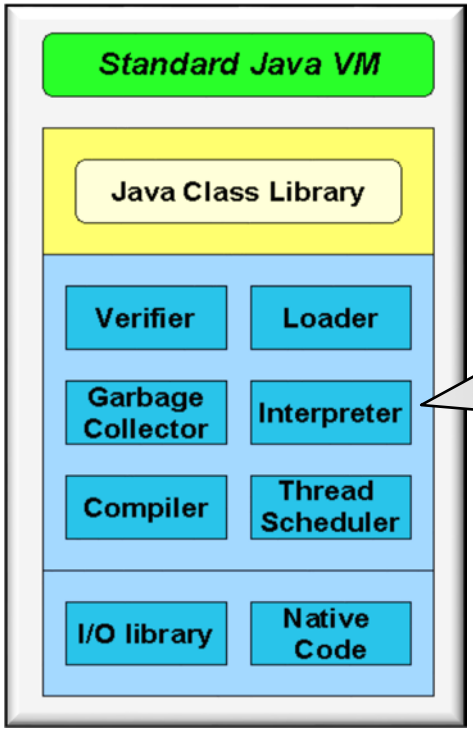

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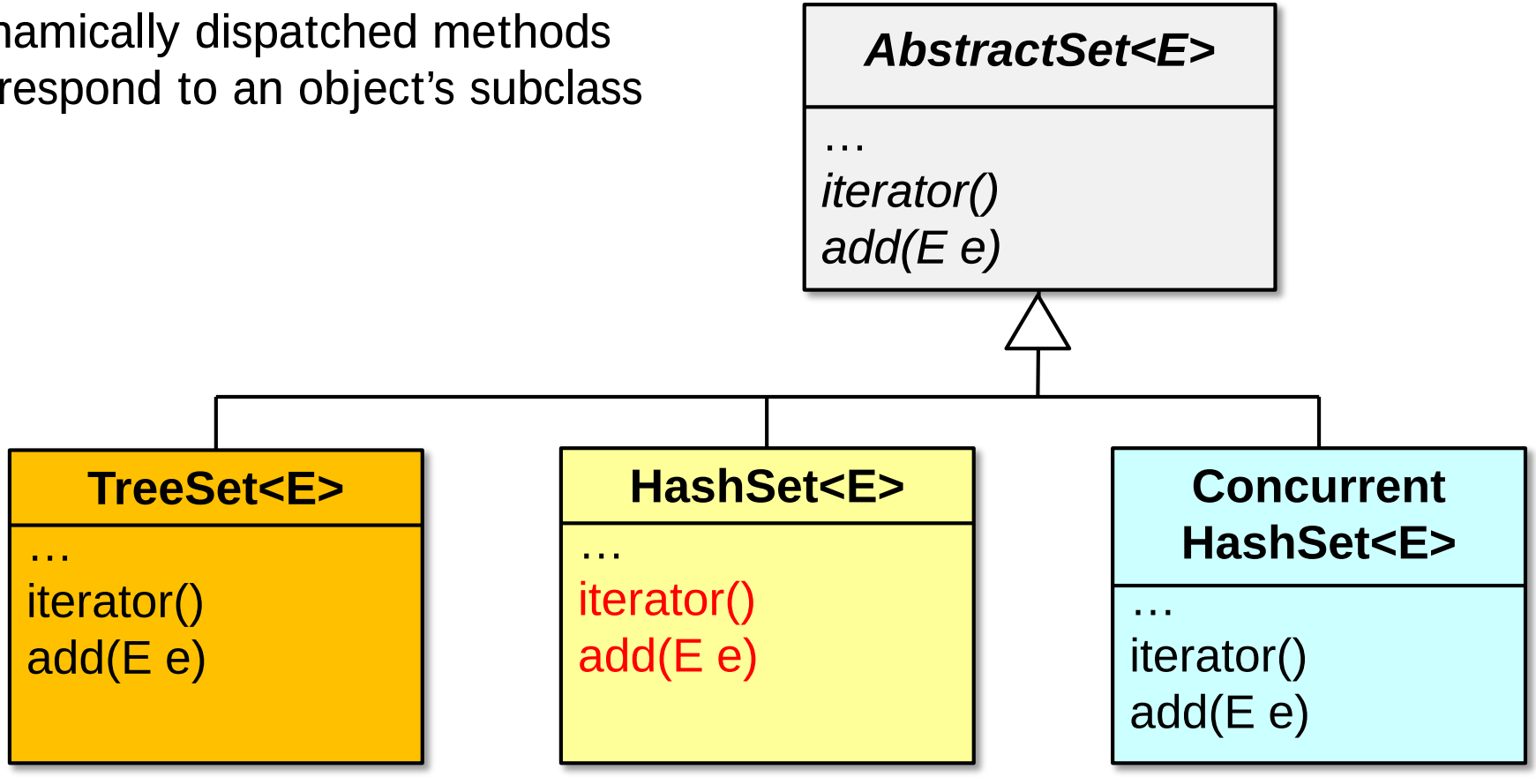
See en.wikipedia.org/wiki/Dynamic_dispatch

Implementing Dynamic Dispatching in Java

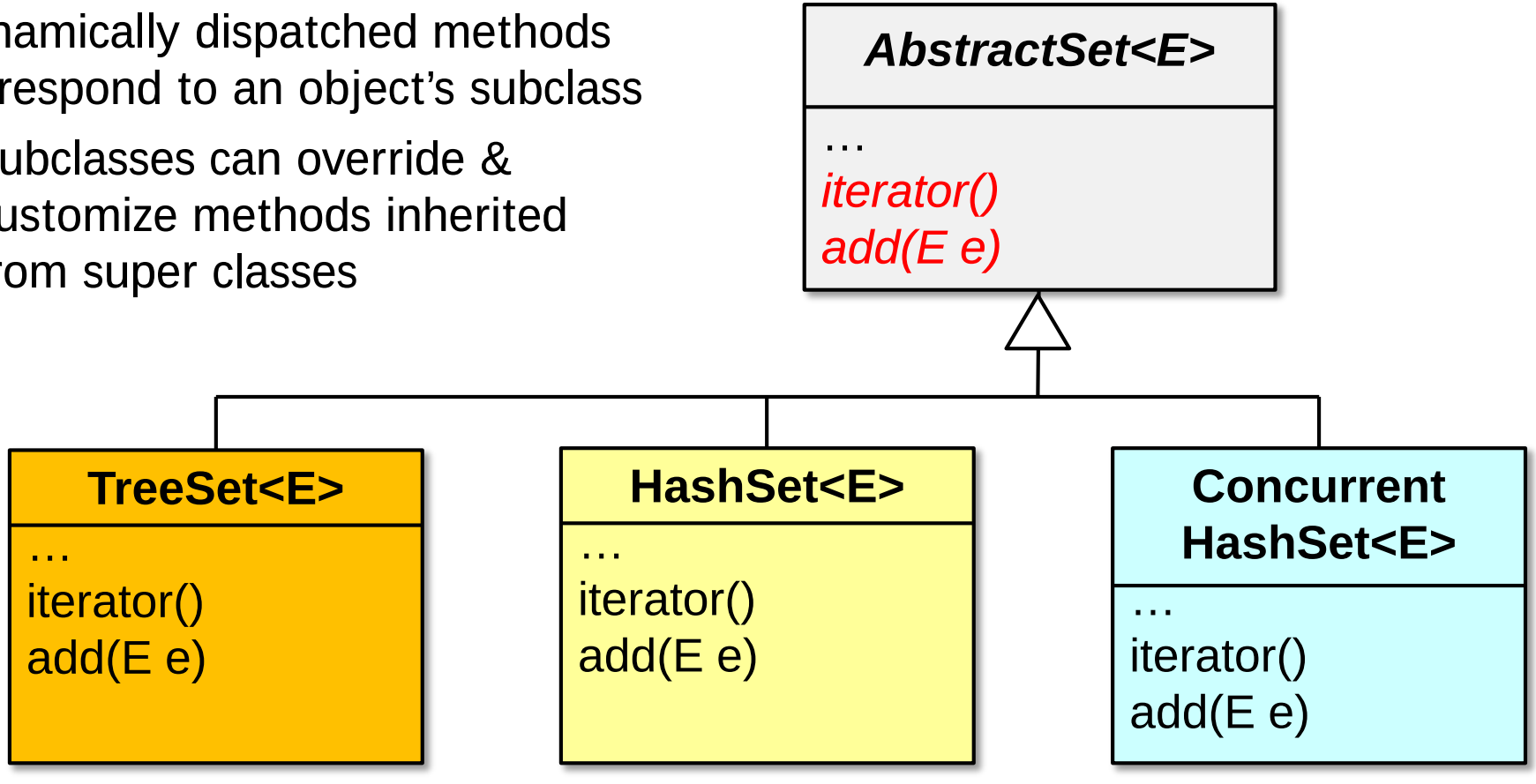
- Dynamically dispatched methods correspond to an object's subclass



See en.wikipedia.org/wiki/Inheritance_(object-oriented_programming)#Subclasses_and_super classes

Implementing Dynamic Dispatching in Java

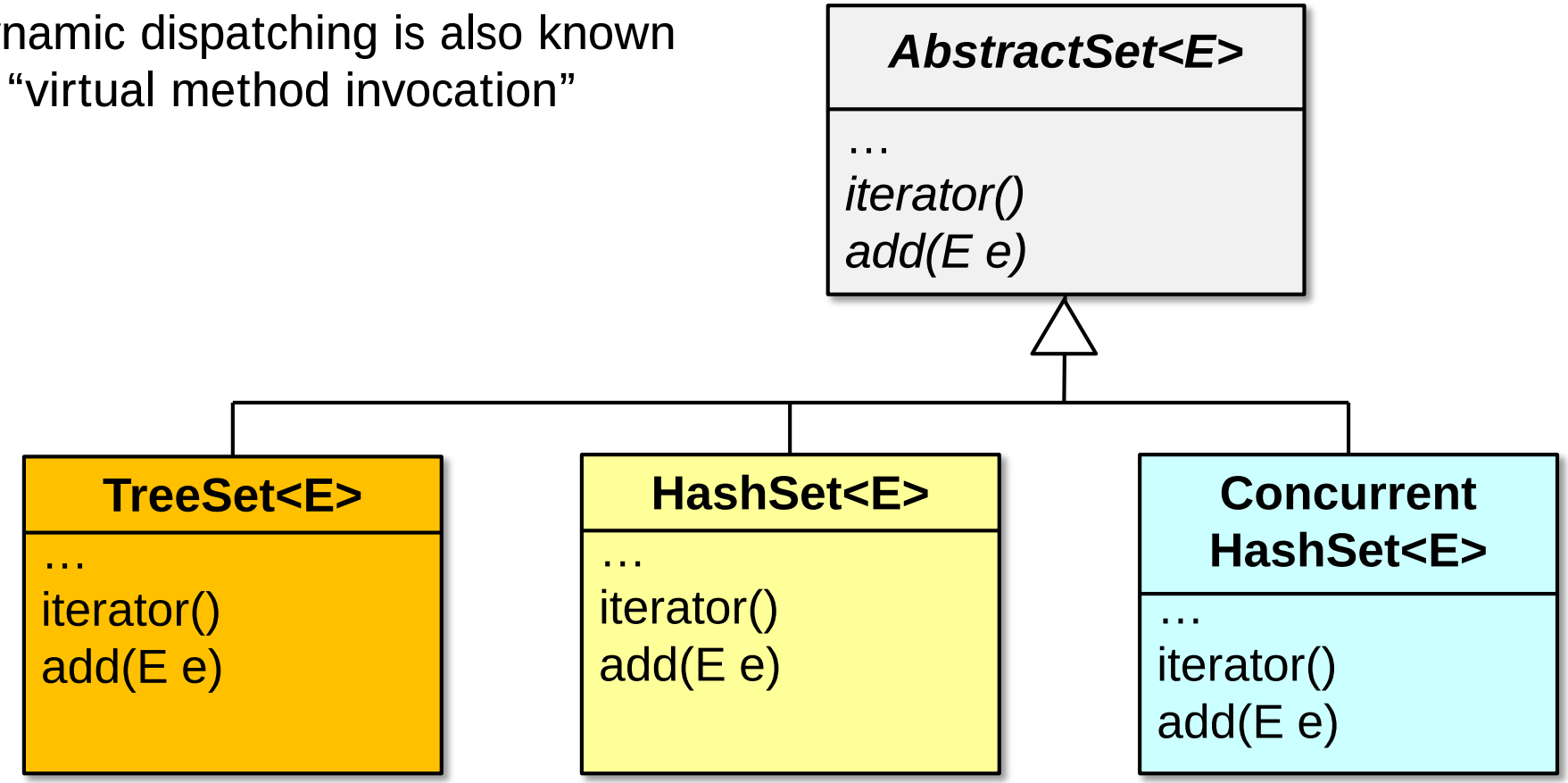
- Dynamically dispatched methods correspond to an object's subclass
  - Subclasses can override & customize methods inherited from super classes



See en.wikipedia.org/wiki/Inheritance_(object-oriented_programming)#Subclasses_and_super_classes

Implementing Dynamic Dispatching in Java

- Dynamic dispatching is also known as “virtual method invocation”



See docs.oracle.com/javase/tutorial/java/IandI/polymorphism.html

Implementing Dynamic Dispatching in Java

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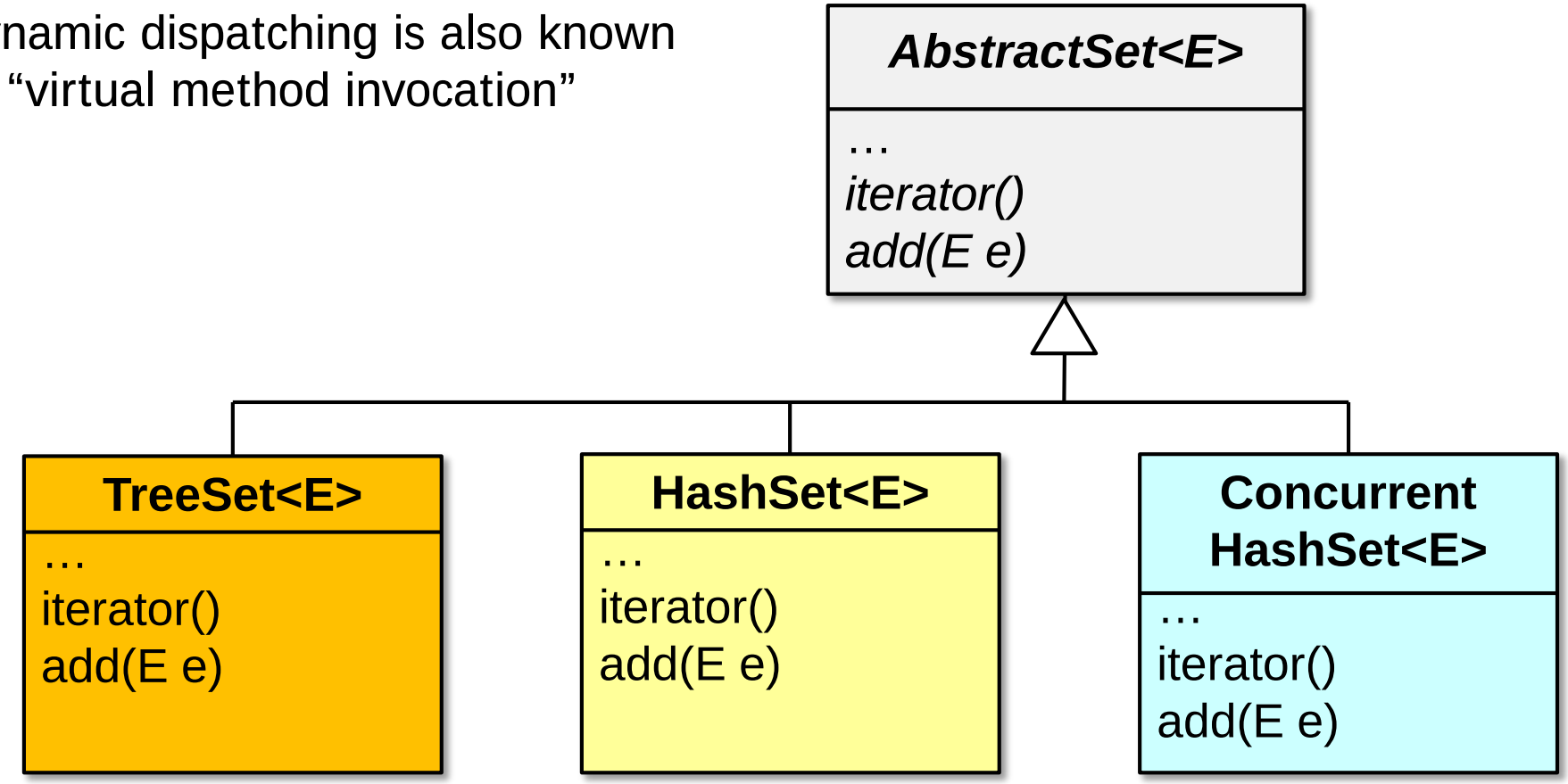
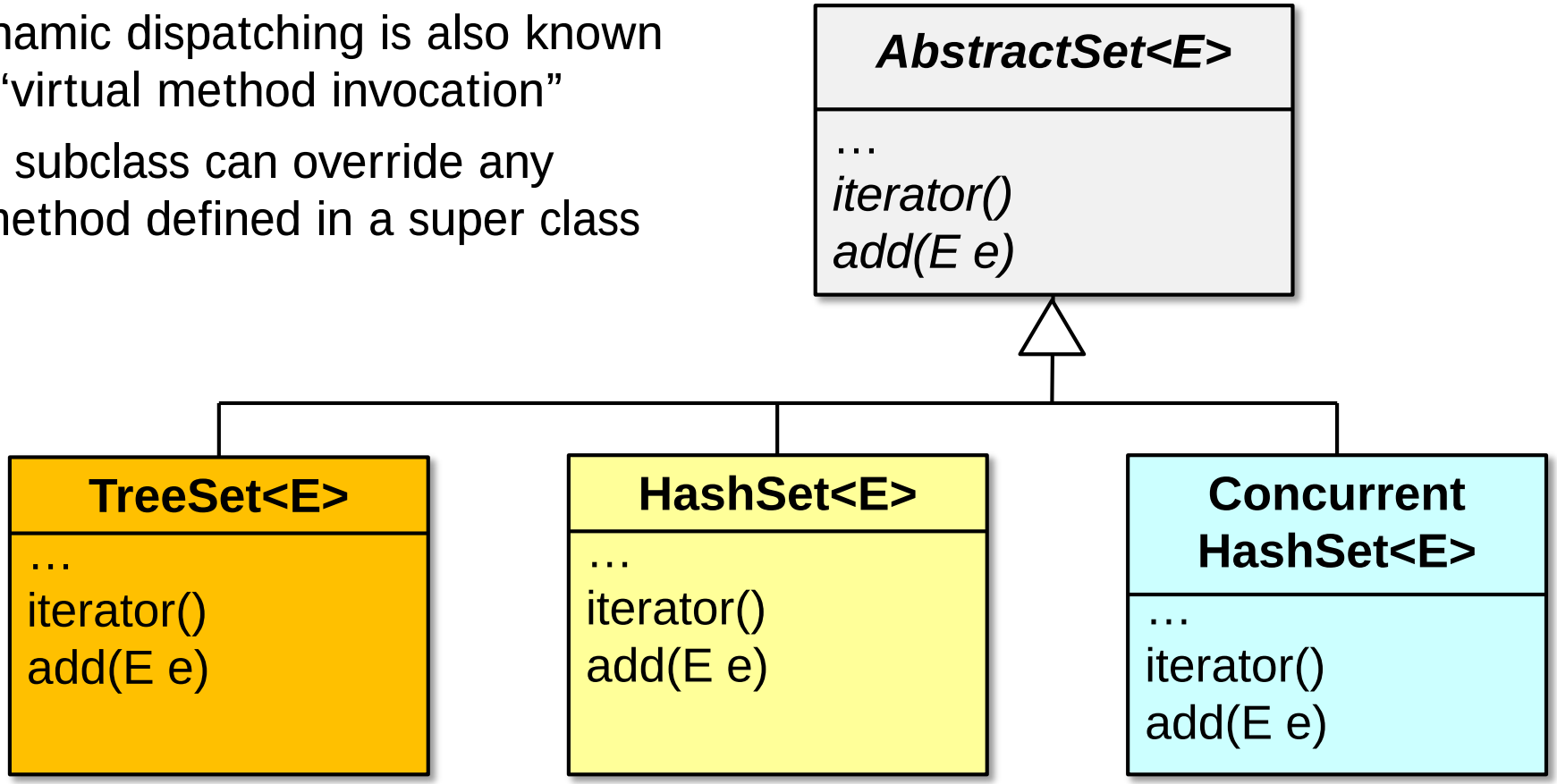


Dynamic dispatching is the default method dispatching mechanism in Java

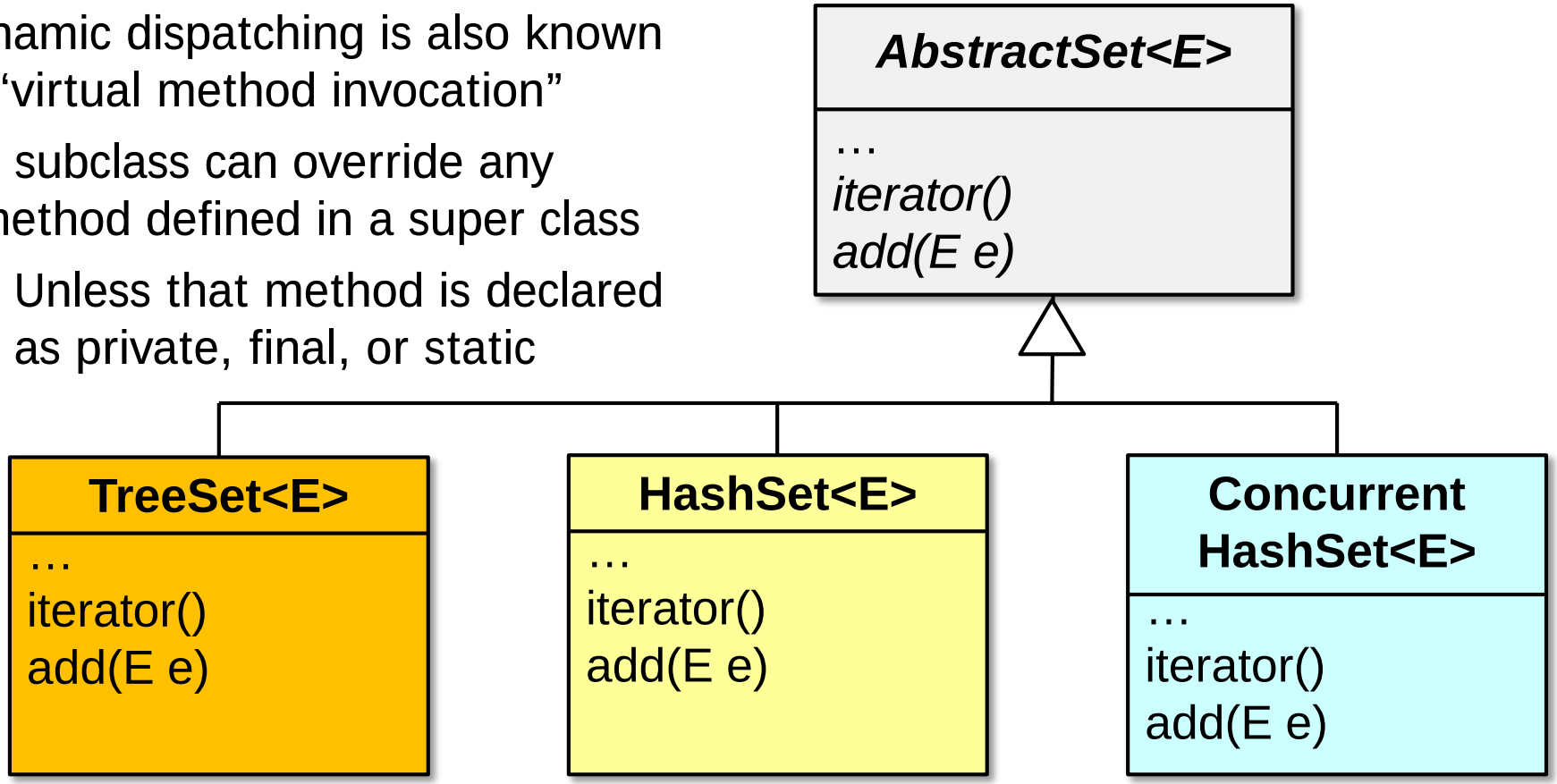
Implementing Dynamic Dispatching in Java

- Dynamic dispatching is also known as “virtual method invocation”
  - A subclass can override any method defined in a super class



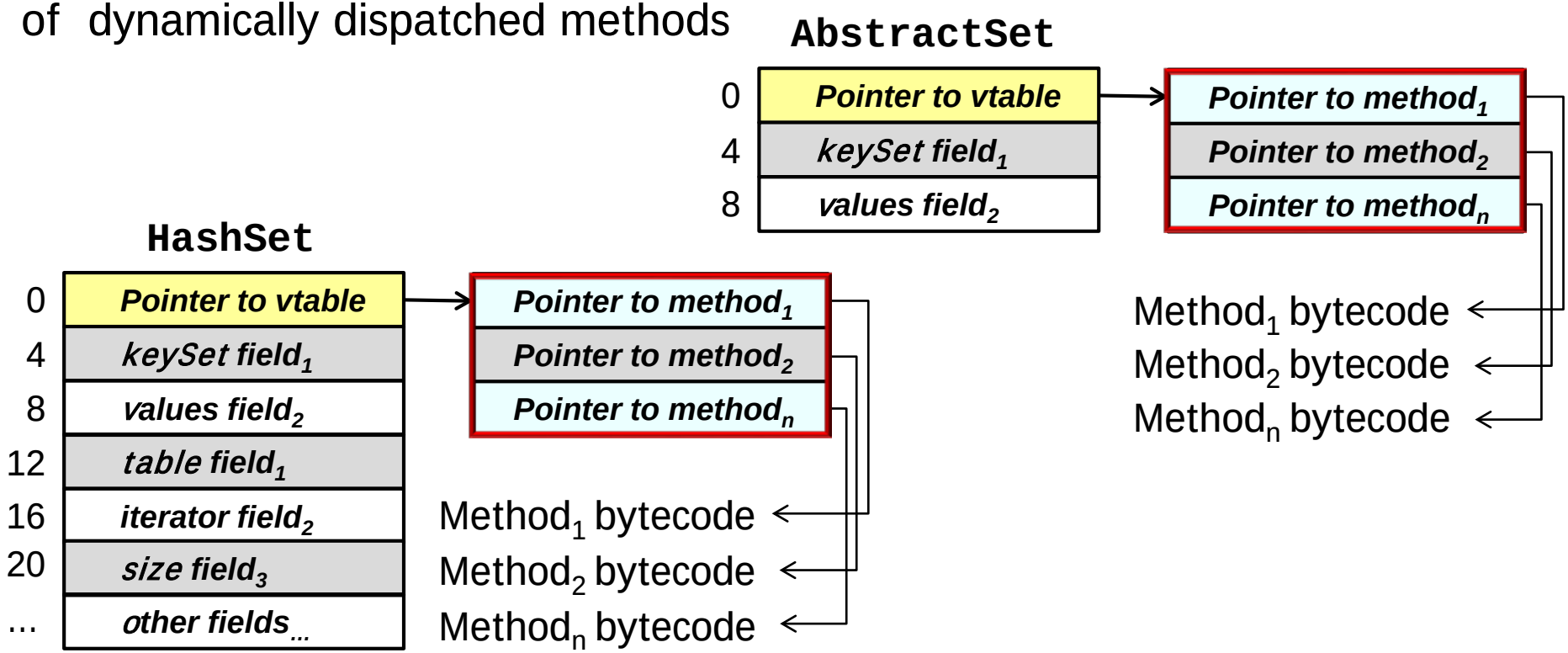
Implementing Dynamic Dispatching in Java

- Dynamic dispatching is also known as “virtual method invocation”
  - A subclass can override any method defined in a super class
    - Unless that method is declared as private, final, or static



Implementing Dynamic Dispatching in Java

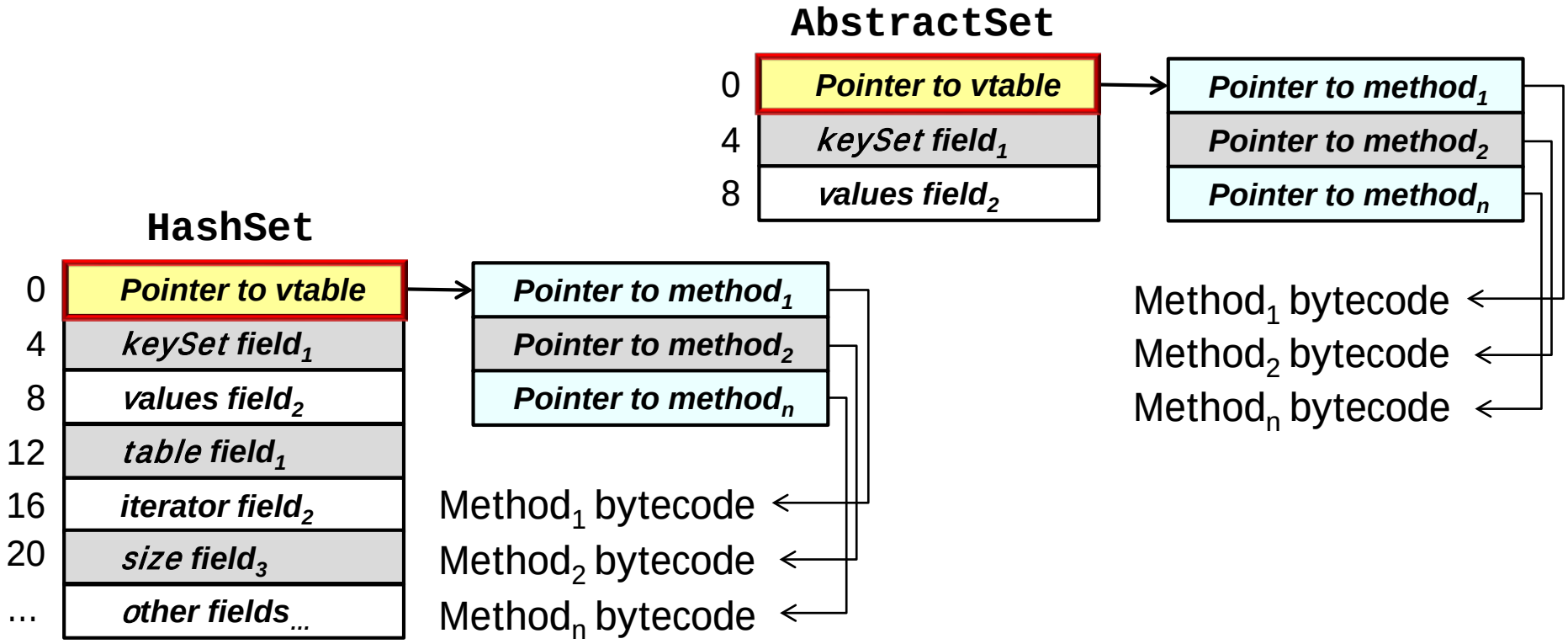
- Each Java class typically has a virtual table (vtable) that contains addresses of dynamically dispatched methods



See en.wikipedia.org/wiki/Virtual_method_table

Implementing Dynamic Dispatching in Java

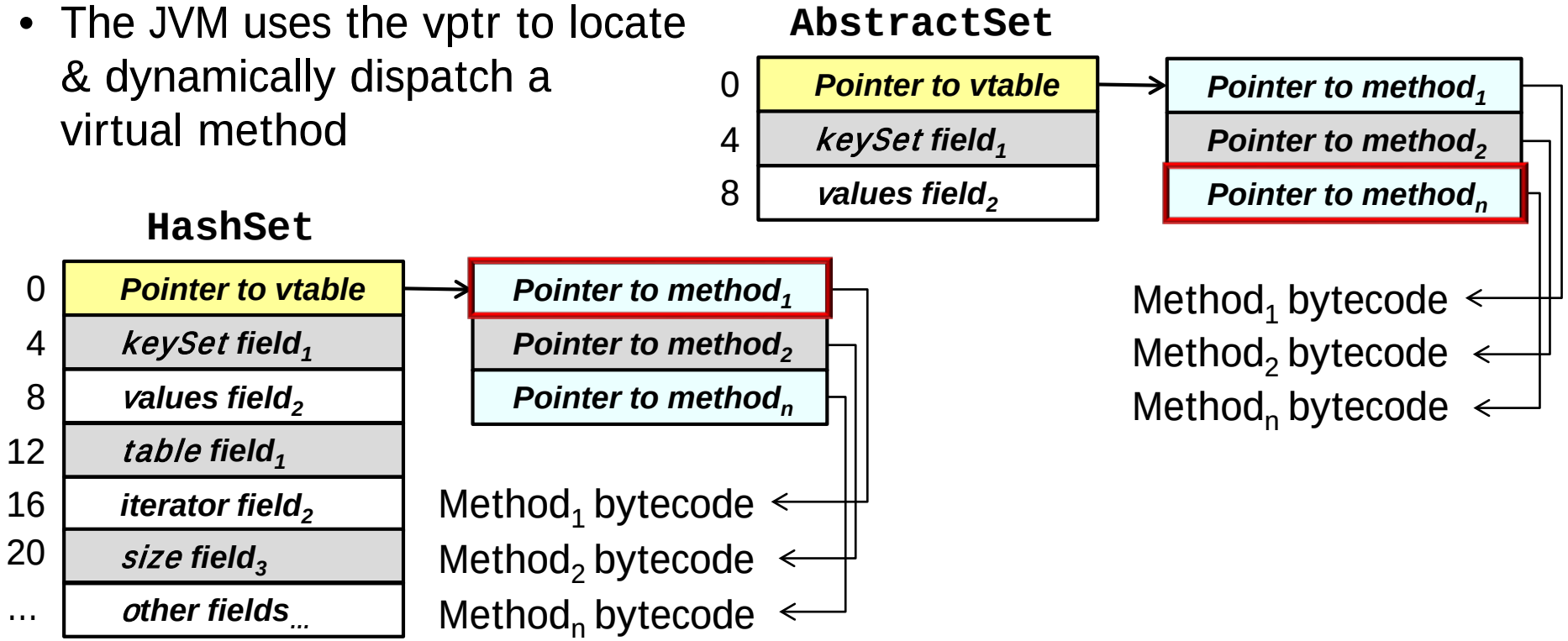
- Each Java object contains a pointer to the vtable (vptr) of its class



See en.wikipedia.org/wiki/Polymorphism_(computer_science)#Subtyping

Implementing Dynamic Dispatching in Java

- Each Java object contains a pointer to the vtable (vptr) of its class
  - The JVM uses the vptr to locate & dynamically dispatch a virtual method



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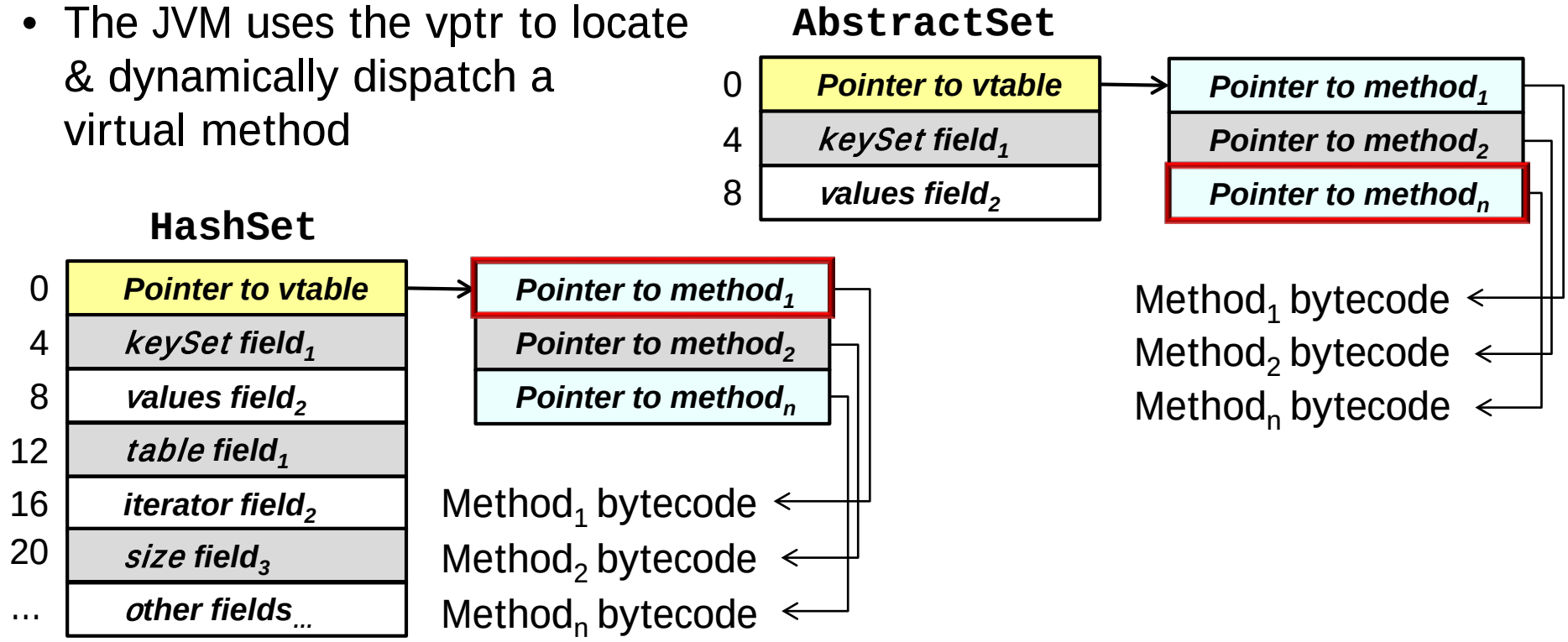
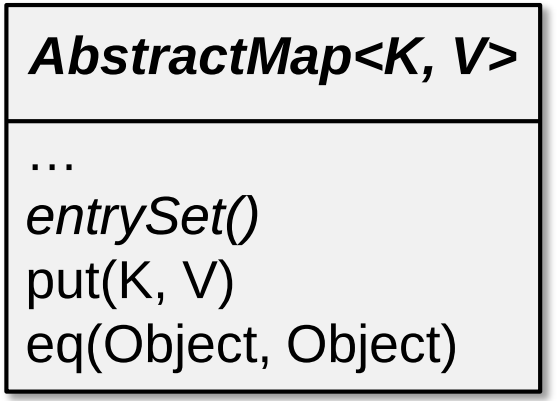
  - The JVM uses the vptr to locate & dynamically dispatch a virtual method



See en.wikipedia.org/wiki/Late_binding#Late_binding_in_Java

Implementing Static Dispatching in Java

- Java also supports static method dispatching, where a method implementation is selected at compile-time



See en.wiktionary.org/wiki/static_dispatch

Implementing Static Dispatching in Java

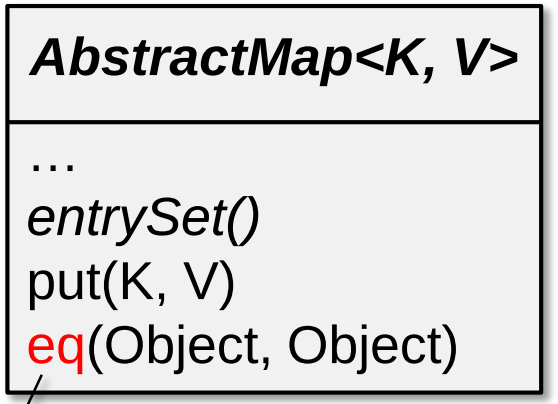
- Java also supports static method dispatching, where a method implementation is selected at compile-time
  - e.g., Java private, final, & static methods

AbstractMap<K, V>
… *entrySet()* put(K, V) eq(Object, Object)

Statically dispatched methods can be implemented & optimized more efficiently

Implementing Static Dispatching in Java

- Java also supports static method dispatching, where a method implementation is selected at compile-time
  - e.g., Java private, final, & static methods




```
static boolean eq(Object o1, Object o2) {
  return o1 == null ? o2 == null : o1.equals(o2);
}
```

See docs.oracle.com/javase/8/docs/api/java/util/AbstractMap.html

Implementing Static Dispatching in Java

- Statically dispatched methods play an important role in Java apps that value performance more than extensibility

e.g., apps where the right answer delivered too late becomes the wrong answer

End of Overview of Java's Support for Polymorphism