Understand Java's Key Functional Programming Concepts & Features

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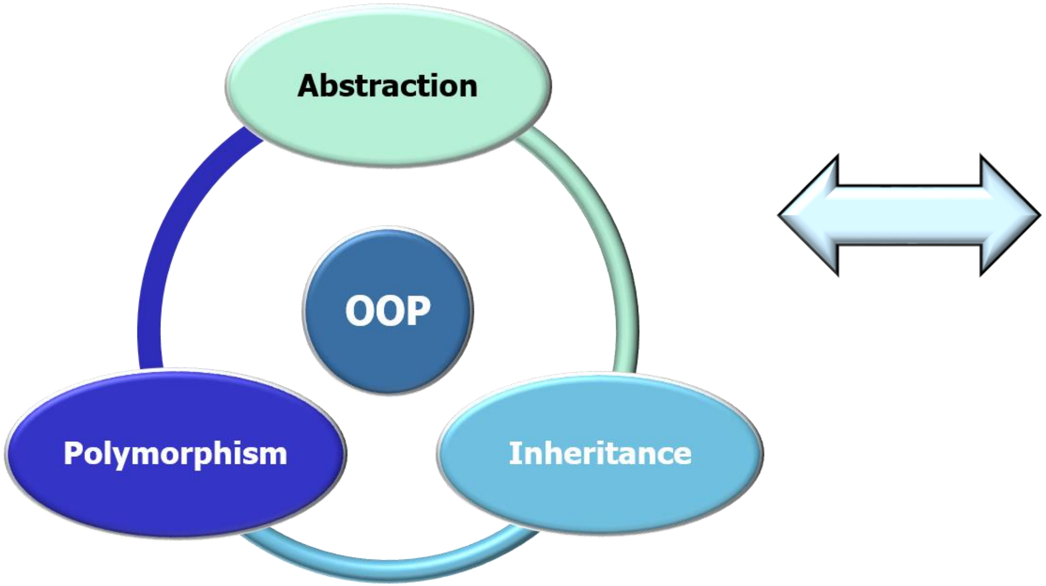
Learning Objectives in this Lesson

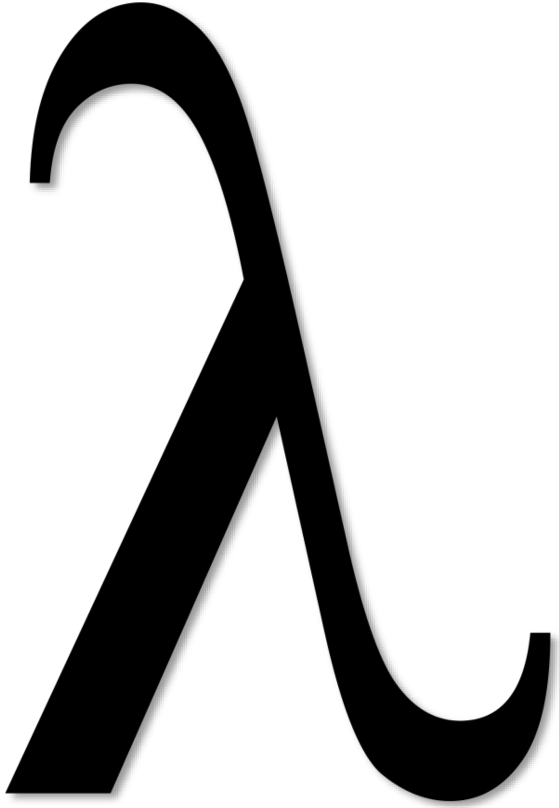
- Understand key functional programming concepts & features supported by Java

These functional programming features were added in Java 8 & expanded later

Learning Objectives in this Lesson

- Understand key functional programming concepts & features supported by Java
- Know how to compare & contrast functional programming & object-oriented programming





Key Functional Programming Concepts in Java

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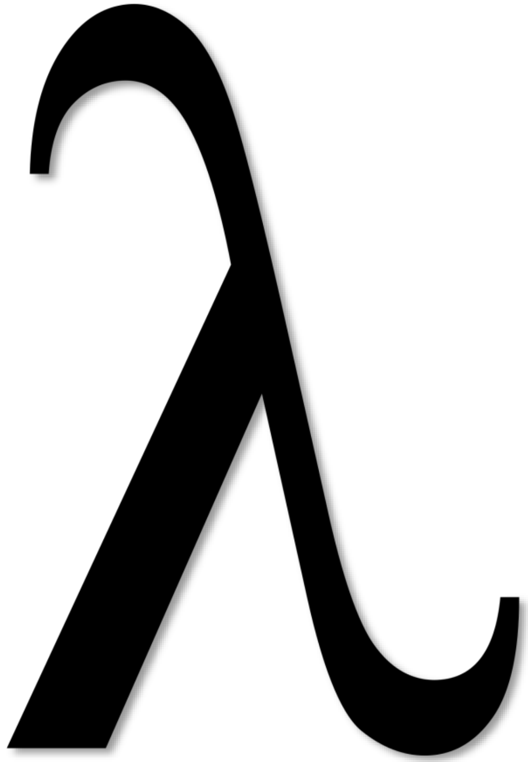
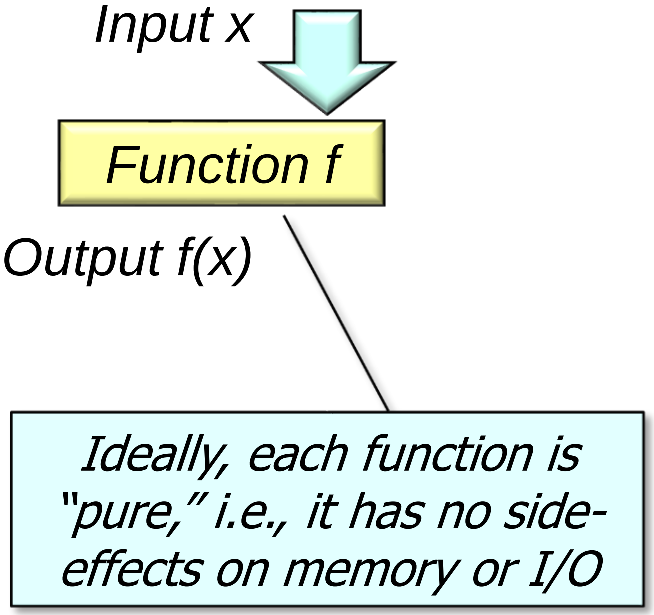
- Functional programming has its roots in lambda calculus



See en.wikipedia.org/wiki/Functional_programming

Key Functional Programming Concepts in Java

- Functional programming has its roots in lambda calculus, e.g.,
  - Computations are treated as evaluation of math functions



See en.wikipedia.org/wiki/Functional_programming#Pure_functions

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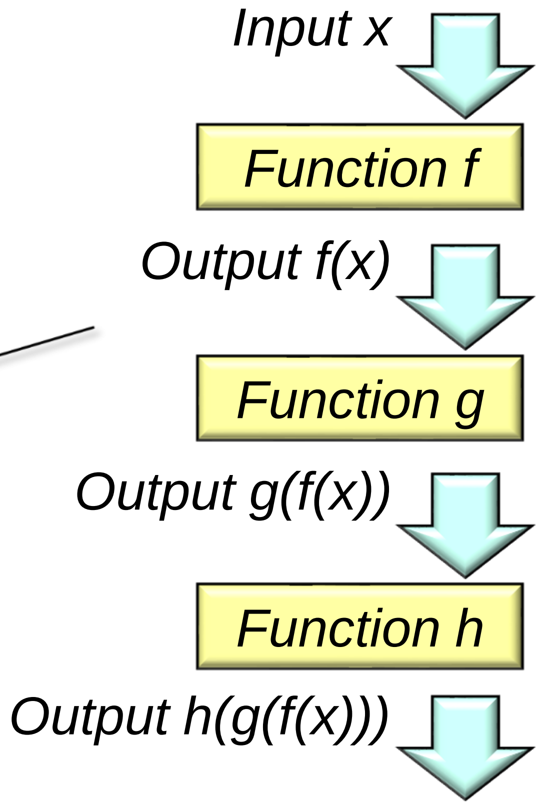

Note "function composition": the output of one function serves as the input to the next function, etc.

See martinfowler.com/articles/collection-pipeline

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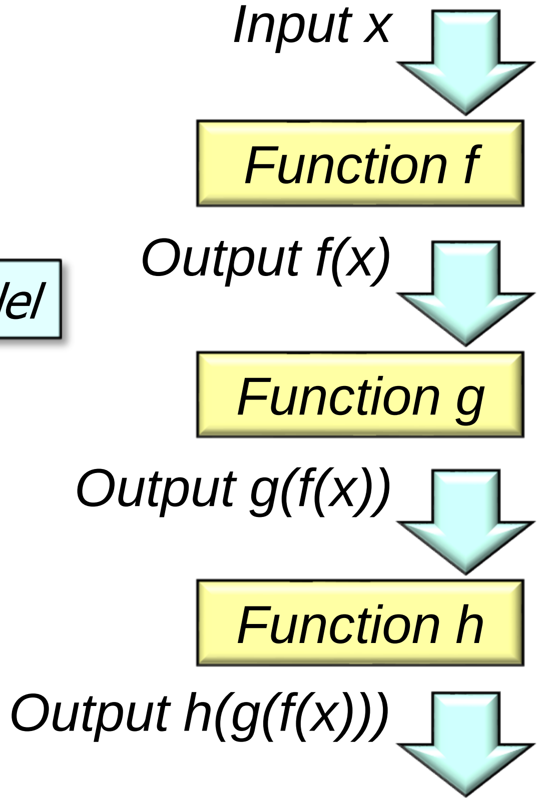
Functionally compute the 'nth' factorial in parallel

```
long factorial
        (long n) {
  return LongStream
    .rangeClosed(1, n)
    .parallel()
    .reduce(1,
        (a, b) -> a * b);
}
```



See github.com/douglascraigschmidt/LiveLessons/tree/master/Java8/ex16

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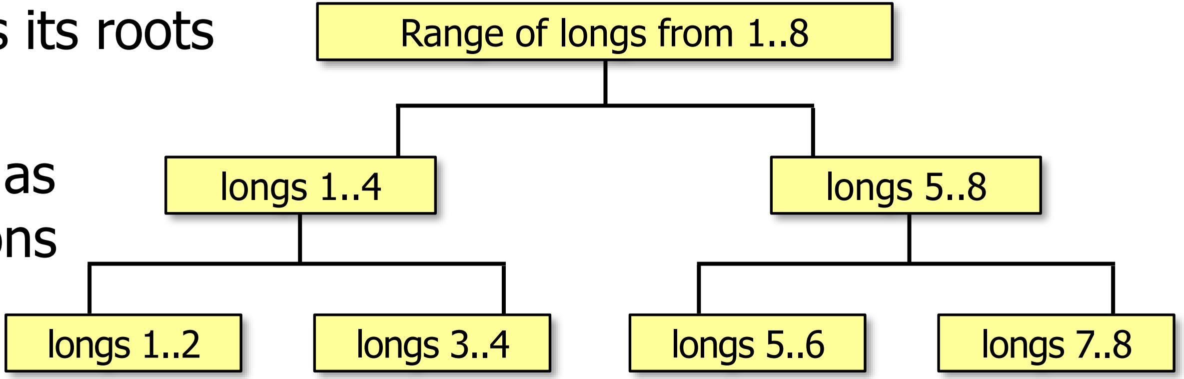


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Generate a stream of longs from 1 to n in parallel (where n == 8)

See www.baeldung.com/java-8-streams

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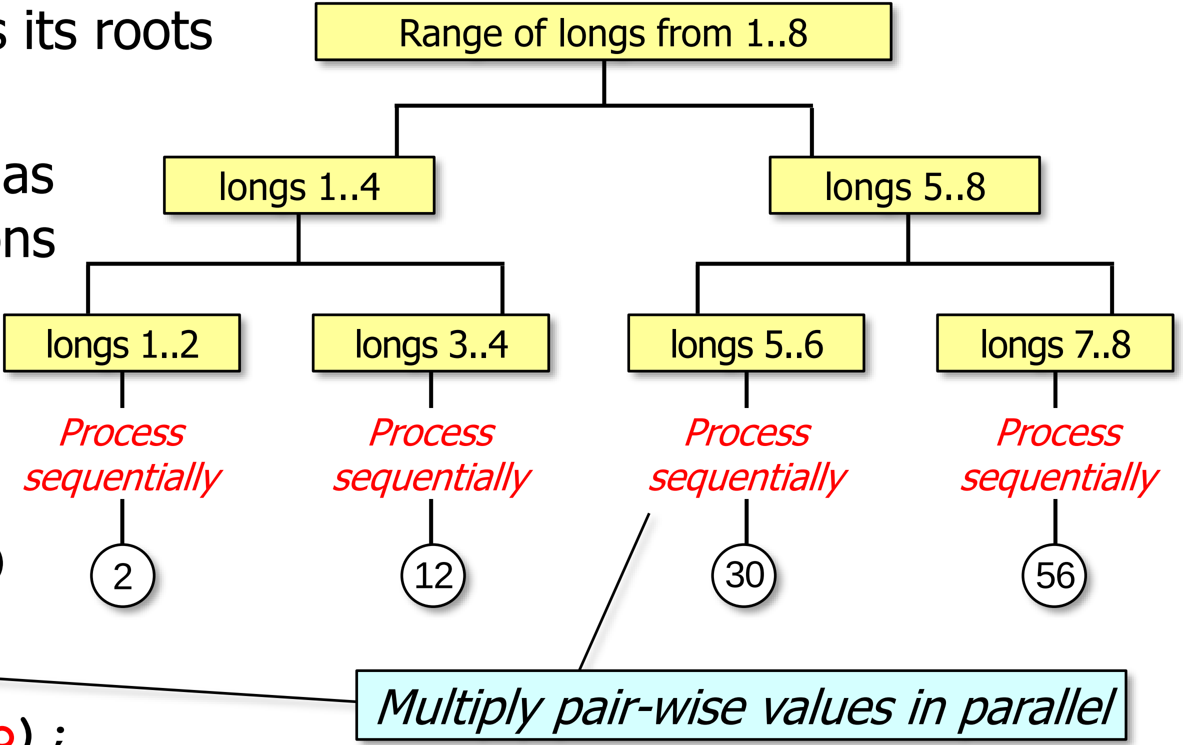

See docs.oracle.com/javase/tutorial/collections/streams/parallelism.html

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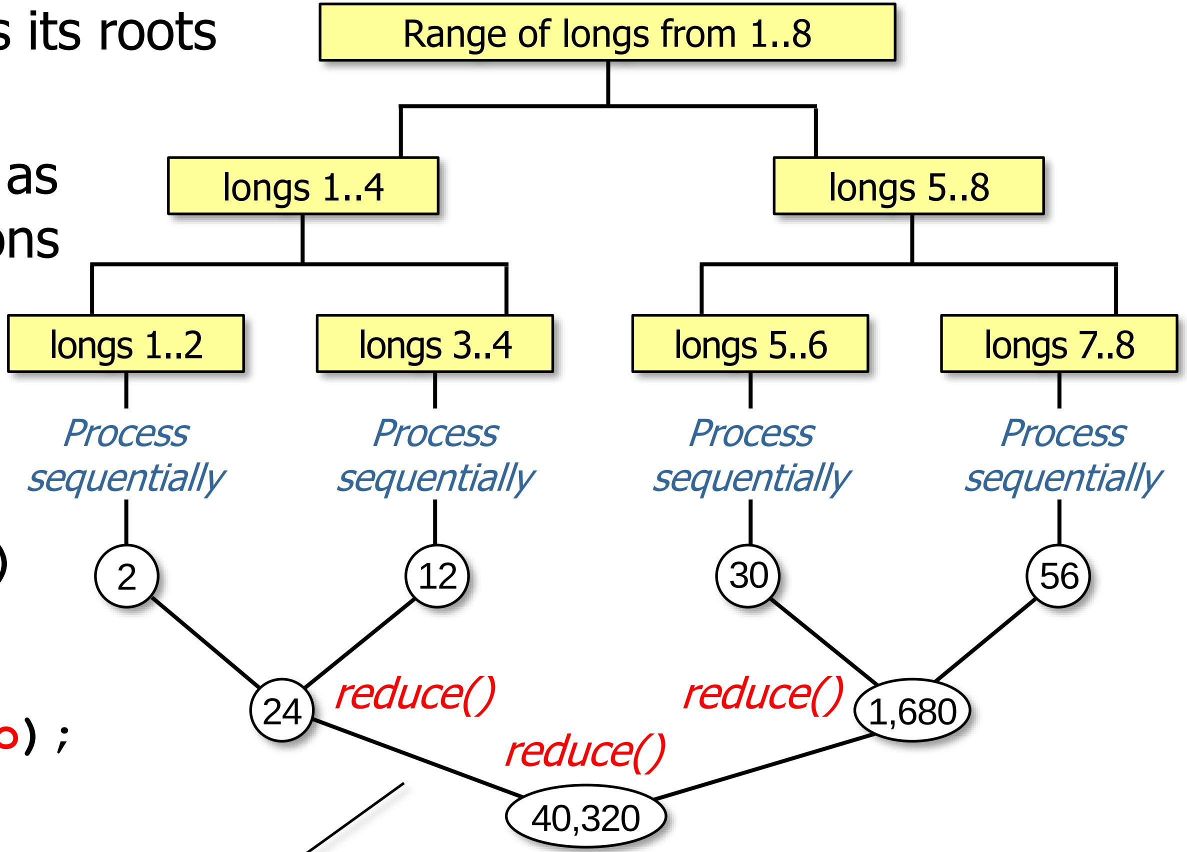

Successively combine two immutable long values & produce a new one

Key Functional Programming Concepts in Java

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  - Computations are treated as evaluation of math functions
  - Changing state & mutable shared data are discouraged to avoid various hazards

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

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```
long factorial(long n) {
  Total t = new Total();
  LongStream.rangeClosed(1, n)
            .parallel()
            .forEach(t::mult);
  return t.mTotal;
}
```

```
class Total {
  public long mTotal = 1;

  public void mult(long n)
  { mTotal *= n; }
}
```

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Shared mutable state

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Run in parallel

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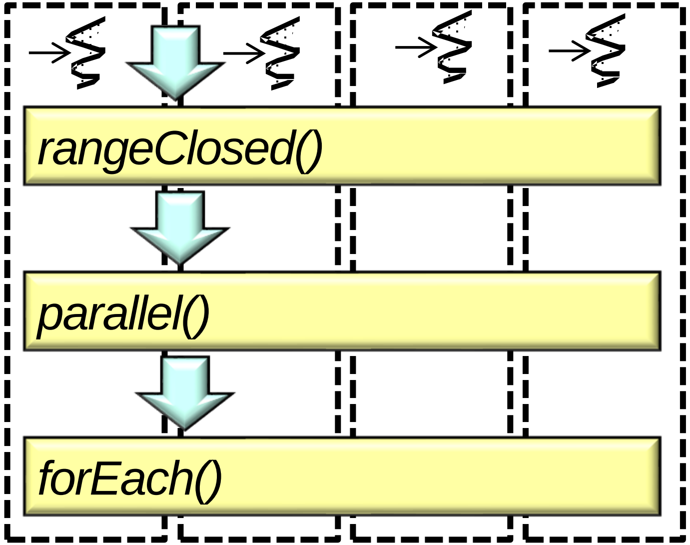

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class Total {
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Beware of race conditions!!!

See en.wikipedia.org/wiki/Race_condition#Software

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```

Beware of inconsistent memory visibility

```
class Total {
  public long mTotal = 1;

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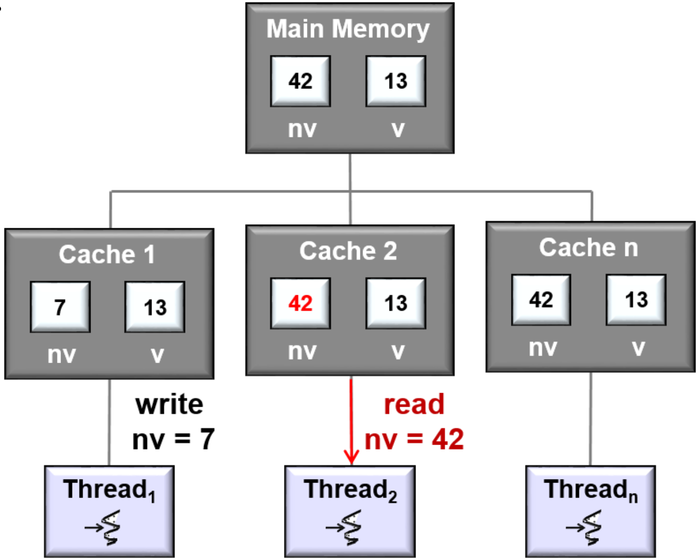
}
```



See jeremymanson.blogspot.com/2007/08/atomicity-visibility-and-ordering.html

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class Total {
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```

Only you can prevent concurrency hazards!

In Java *you* must avoid these hazards, i.e., the compiler & JVM won't save you..

Key Functional Programming Concepts in Java

- Functional programming has its roots in lambda calculus, e.g.,
  - Computations are treated as evaluation of math functions
  - Changing state & mutable shared data are discouraged to avoid various hazards
  - Instead, focus is on "immutable" objects

See docs.oracle.com/javase/tutorial/essential/concurrency/immutable.html

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- Functional programming has its roots in lambda calculus, e.g.,
  - Computations are treated as evaluation of math functions
  - Changing state & mutable shared data are discouraged to avoid various hazards
  - Instead, focus is on "immutable" objects
    - Immutable object state cannot change after it is constructed

```
final class String {
  private final char value[];
  ...

  public String(String s) {
    value = s;
    ...
  }

  public int length() {
    return value.length;
  }
  ...
}
```

See www.baeldung.com/java-immutable-object

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    - Java String is a common example of an immutable object

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final class String {
  private final char value[];
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  public String(String s) {
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See docs.oracle.com/javase/8/docs/api/java/lang/String.html

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  - Instead, focus is on "immutable" objects
    - Immutable object state cannot change after it is constructed
    - Java String is a common example of an immutable object
      - Fields are final & only accessor methods

```
final class String {
  private final char value[];
  ...

  public String(String s) {
    value = s;
    ...
  }

  public int length() {
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```

See www.programcreek.com/2013/04/why-string-is-immutable-in-java

Functional vs. Object-Oriented Programming in Java

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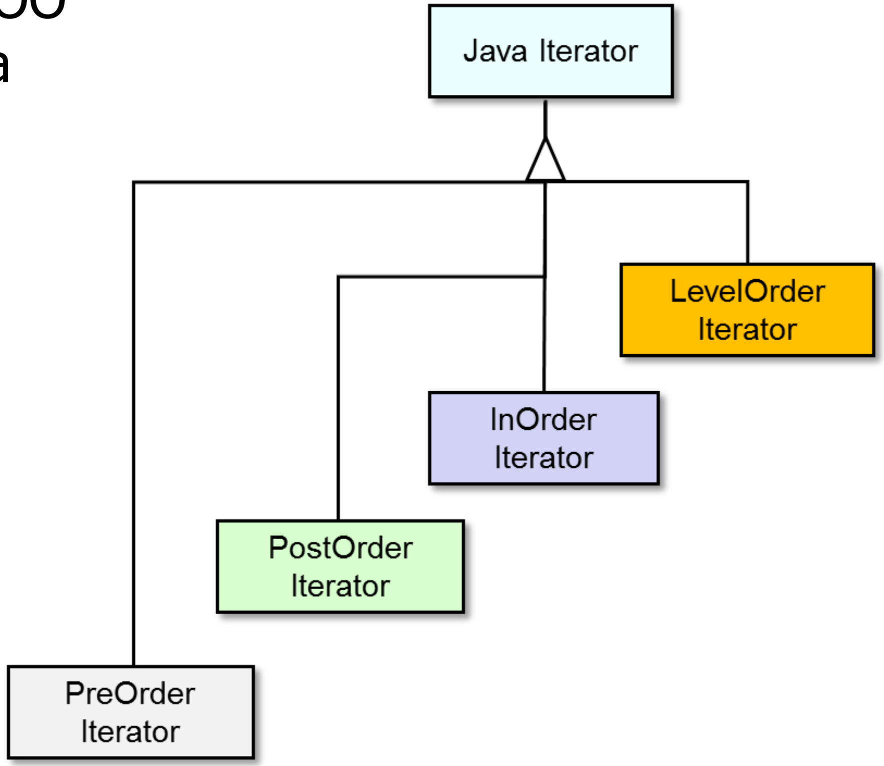
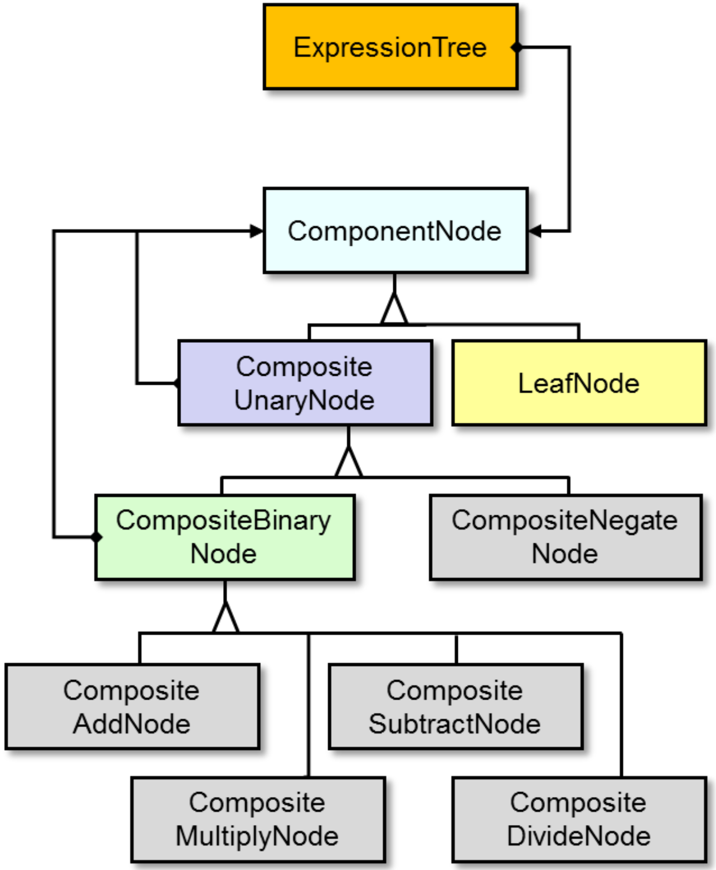
- In contrast to functional programming, OO programming employs "hierarchical data abstraction"



See en.wikipedia.org/wiki/Object-oriented_design

Functional vs. Object-Oriented Programming in Java

- In contrast to functional programming, OO programming employs "hierarchical data abstraction", e.g.
  - Components are based on stable *class* roles & relationships extensible via inheritance & dynamic binding



See en.wikipedia.org/wiki/Object-oriented_programming

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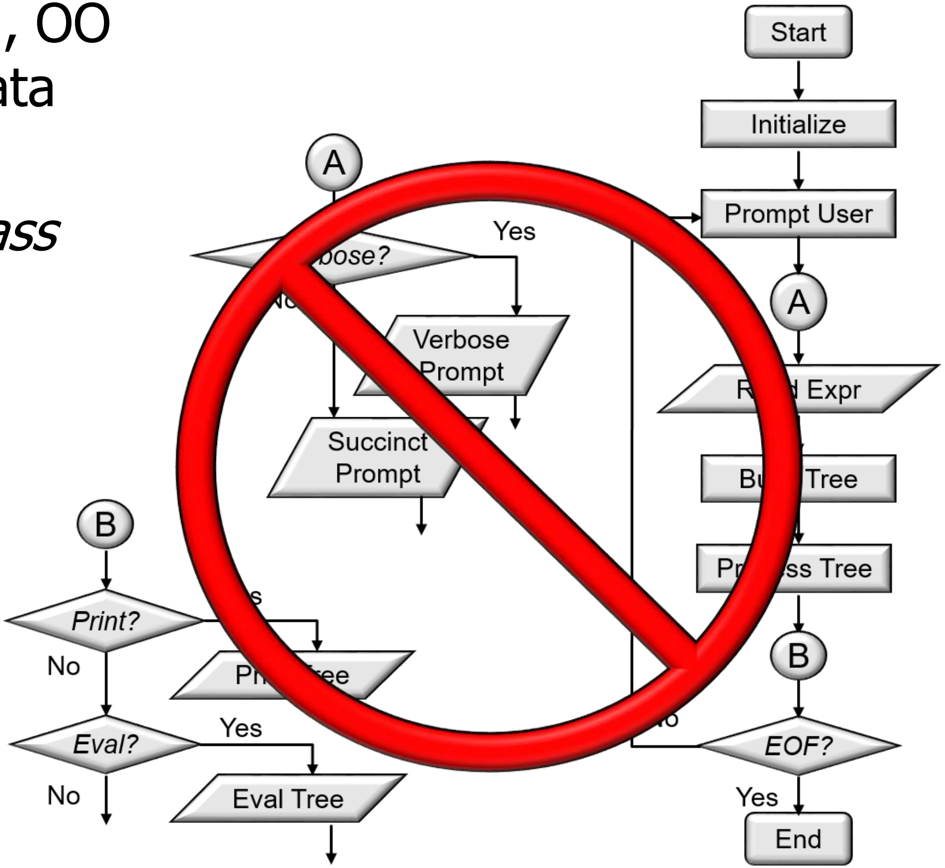
  - Components are based on stable *class* roles & relationships extensible via inheritance & dynamic binding
    - Rather than algorithmic actions implemented as functions



See www.drdobbs.com/windows/software-complexity-bringing-order-to-ch/199901062

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- In contrast to functional programming, OO programming employs "hierarchical data abstraction", e.g.
  - Components are based on stable *class* roles & relationships extensible via inheritance & dynamic binding
  - State is encapsulated by methods that perform imperative statements

```
Tree tree = ...;
Visitor printVisitor =
    makeVisitor(...);

for(Iterator<Tree> iter =
        tree.iterator();
    iter.hasNext();)
  iter.next()
    .accept(printVisitor);
```

See en.wikipedia.org/wiki/Imperative_programming

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Access & update internal iterator state

State is often "mutable" in OO programs

End of Understand Java's Key Functional Programming Concepts & Features