

ORACLE

To Java 18 and Beyond!

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Important Notes

- Ask questions
- Reach out:
Twitter: @BillyKorando
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- Link to slides👉 <https://github.com/wkorando/to-java-18-and-beyond>

Agenda

- New Language Features
- New Runtime Features
- Deprecations
- Removals
- And other changes to know about
- The Future



- <https://dev.java>
- <https://inside.java>
- <https://youtube.com/java>
- Inside Java Podcast
- Inside Java Newscast
- #SipOfJava
- #JEPCafé

New Language Features

Text Blocks

Added in Java 15
JEP 378

Text Blocks

```
String simpleJSONMessage = "{\n" + //\t\"firstName\": \"Billy\", \n" + //\t\"lastName\": \"Korando\", \n" + //\t\"jobTitle\": \"Java Developer Advocate\", \n" + //\t\"twitterHandle\": \"@BillyKorando\" \n" + //"}";
```

Text Blocks

```
String simpleJSONMessage = """
{
    "firstName": "Billy",
    "lastName": "Korando",
    "jobTitle": "Java Developer Advocate",
    "twitterHandle": "@BillyKorando"
}
""";
```

Text Blocks

```
String simpleJSONMessage = """
{
    "firstName": "%s",
    "lastName": "%s",
    "jobTitle": "%s",
    "twitterHandle": "%s"
}
""";  
  
System.out.println(simpleJSONMessage.
    formatted("Billy",
    "Korando",
    "Java Developer Advocate",
    "@BillyKorando"));
```

Text Blocks

```
String aReallyLongLine = """
    Lorem ipsum dolor sit amet, consectetur adipiscing elit, \
    sed do eiusmod tempor incididunt ut labore et dolore \
    magna aliqua. \
""";  
  
System.out.println(aReallyLongLine);
```

Switch Updates

Added in Java 14

JEP 361

Switch Updates

```
switch(d){  
    case 1:  
        System.out.println("Sunday");  
        break;  
    case 2:  
        System.out.println("Monday");  
        break;  
    case 3:  
        System.out.println("Tuesday");  
        break;  
    case 4:  
        System.out.println("Wednesday");  
        break;  
    case 5:  
        System.out.println("Thursday");  
        break;  
    case 6:  
        System.out.println("Friday");  
  
    case 7:  
        System.out.println("Saturday");  
        break;  
}
```

Switch Updates

```
switch(d){  
    case 1 -> System.out.println("Sunday");  
    case 2 -> System.out.println("Monday");  
    case 3 -> System.out.println("Tuesday");  
    case 4 -> System.out.println("Wednesday");  
    case 5 -> System.out.println("Thursday");  
    case 6 -> System.out.println("Friday");  
    case 7 -> System.out.println("Saturday");  
}
```

Switch Updates

```
String day = switch(d){  
    case 1 -> "Sunday";  
    case 2 -> "Monday";  
    case 3 -> "Tuesday";  
    case 4 -> "Wednesday";  
    case 5 -> "Thursday";  
    case 6 -> "Friday";  
    case 7 -> "Saturday";  
    default -> throw new IllegalArgumentException();  
}
```

Switch Updates

```
String day = switch(d){  
    case 1 -> "Sunday";  
    case 2 -> "Monday";  
    case 3 -> "Tuesday";  
    case 4 -> "Wednesday";  
    case 5 -> "Thursday";  
    case 6 -> {  
        System.out.println("Ladies and Gentlemen, the Weekend");  
        yield "Friday";  
    }  
    case 7 -> "Saturday";  
    default -> throw new IllegalArgumentException();  
}
```

Switch Updates

```
String day = switch(d){  
    case 1:  
        yield "Sunday";  
    case 2:  
        yield "Monday";  
    case 3:  
        yield "Tuesday";  
    case 4:  
        yield "Wednesday";  
    case 5:  
        yield "Thursday";  
    case 6:  
        yield "Friday";  
    case 7:  
        yield "Saturday";  
    default:  
        throw new IllegalArgumentException();  
}
```

Switch Updates

```
enum DaysOfWeek {  
    SUNDAY, MONDAY, TUESDAY, WEDNESDAY, THURSDAY, FRIDAY, SATURDAY;  
}  
  
DaysOfWeek dayOfWeek = [someDayOfWeek]  
  
String day = switch(dayOfWeek){  
    case SUNDAY -> "Sunday";  
    case MONDAY -> "Monday";  
    case TUESDAY -> "Tuesday";  
    case WEDNESDAY -> "Wednesday";  
    case THURSDAY -> "Thursday";  
    case FRIDAY -> "Friday";  
    case SATURDAY -> "Saturday";  
}
```

Switch Updates

```
enum DaysOfWeek {
    SUNDAY, MONDAY, TUESDAY, WEDNESDAY, THURSDAY, FRIDAY, SATURDAY;
}

String day = switch(dayOfWeek){
    case SUNDAY :
        yield "Sunday";
    case MONDAY :
        yield "Monday";
    case TUESDAY :
        yield "Tuesday";
    case WEDNESDAY:
        yield "Wednesday";
    case THURSDAY:
        yield "Thursday";
    case FRIDAY:
        yield "Friday";
    case SATURDAY:
        yield "Saturday";
};
```

Pattern Matching for instanceof

Added in Java 16

JEP 394

Pattern Matching for instanceof

```
Object actuallyAString = "I'm actually a string";  
  
if(actuallyAString instanceof String) {//Test if actuallyAString is a String  
    String nowImAString = //Assign actuallyAString to a variable  
    (String) actuallyAString; //Convert actuallyAString to a String  
  
    System.out.println(nowImAString);  
}
```

Pattern Matching for instanceof

```
Object actuallyAString = "I'm actually a string!";
if(actuallyAString instanceof String nowImAString) {
    System.out.println(nowImAString);
}
```

Predicate

Pattern

Variable

Pattern Matching for instanceof

```
Object actuallyAString = "I'm actually a string!";

if(actuallyAString instanceof String nowImAString) {
    System.out.println(nowImAString);
}

System.out.println(nowImAString); //Compiler error, nowImAString not in scope

boolean isAString = (actuallyAString instanceof String nowImAString);

System.out.println(nowImAString); //Compiler error, nowImAString not in scope
```

In scope where compiler knows pattern variable is set

Pattern Matching for instanceof

```
Object actuallyAString = "I'm actually a string!";

if(actuallyAString instanceof String nowImAString
    || nowImAString.endsWith("!") //Compiler error, nowImAString not in scope
) {
    System.out.println(nowImAString);
}
```

Pattern Matching for instanceof

```
Object actuallyAString = "I'm actually a string";  
  
if(actuallyAString instanceof String nowImAString  
    && nowImAString.endsWith("!")) {  
    System.out.println(nowImAString);  
}
```

Pattern Matching for instanceof

```
Object actuallyAString = "I'm actually a string!";

if (!(actuallyAString instanceof String nowImAString)) {
//...
} else {
    System.out.println(nowImAString);
}

if (!(actuallyAString instanceof String nowImAString)) {
    throw new IllegalArgumentException("Must be a string!");
}

System.out.println(nowImAString);
```

Pattern Matching for instanceof

```
Object actuallyAString = "I'm actually a string!";
String aString = null;

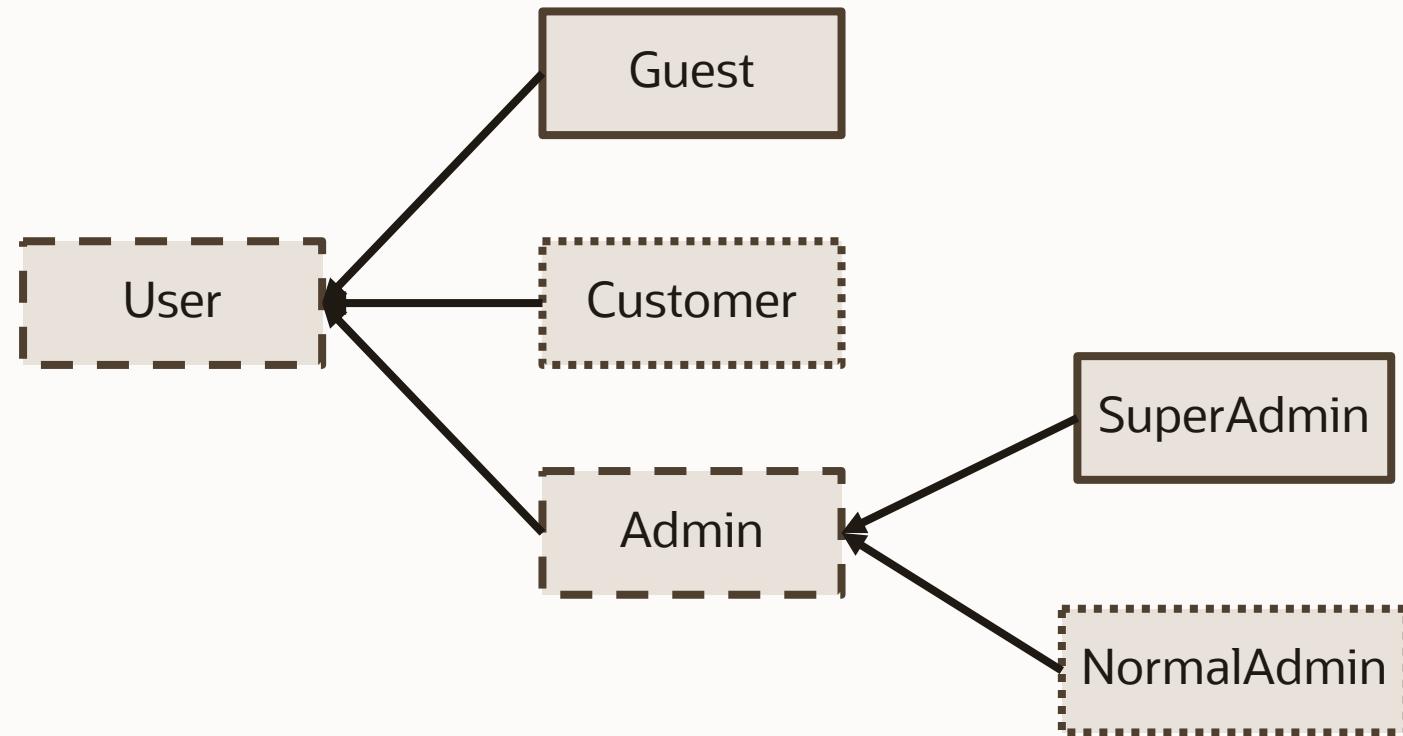
if(actuallyAString instanceof String nowImAString) {
    aString = nowImAString;
}

System.out.println(aString);
```

Sealed Classes

Added in Java 17
JEP 409

Sealed Classes



Sealed Classes

```
public abstract sealed class User
permits Admin, Customer, Guest{



}

public sealed class Admin
extends User permits SuperAdmin, NormalAdmin{



}

public final class Guest extends User {



}

public non-sealed class Customer extends User {



}
```

Sealed Classes

```
public abstract sealed class User
permits Admin, Customer, Guest{



}

public sealed class Admin
extends User permits SuperAdmin, NormalAdmin{



}

public final class Guest extends User {



}

public non-sealed class Customer extends User {



}
```

Records

Added in Java 16
JEP 395

Records

```
String firstName1 = "Billy";
String lastName1 = "Korando";
String title1 = "Java Developer Advocate";
String twitterHandle1 = "@BillyKorando";

String firstName2 = "Sharat";
String lastName2 = "Chander";
String title2 = "Java Developer Advocate";
String twitterHandle2 = "@Sharat_Chander";

class Person{
    private String firstName;
    private String lastName;
    private String title;
    private String twitterHandle;
    public Person(String firstName, String lastName, String title, String twitterHandle) {
        this.firstName = firstName;
        this.lastName = lastName;
        this.title = title;
        this.twitterHandle = twitterHandle;
    }
    @Override
    public int hashCode() {
        final int prime = 31;
        int result = 1;
        result = prime * result + ((firstName == null) ? 0 : firstName.hashCode());
        result = prime * result + ((lastName == null) ? 0 : lastName.hashCode());
        result = prime * result + ((title == null) ? 0 : title.hashCode());
        result = prime * result + ((twitterHandle == null) ? 0 : twitterHandle.hashCode());
        return result;
    }
    @Override
    public boolean equals(Object obj) {
        if (this == obj)
            return true;
        if (obj == null)
            return false;
        if (getClass() != obj.getClass())
            return false;
        Person other = (Person) obj;
        if (firstName == null) {
            if (other.firstName != null)
                return false;
        } else if (!firstName.equals(other.firstName))
            return false;
        if (lastName == null) {
            if (other.lastName != null)
                return false;
        } else if (!lastName.equals(other.lastName))
            return false;
        if (title == null) {
            if (other.title != null)
                return false;
        } else if (!title.equals(other.title))
            return false;
        if (twitterHandle == null) {
            if (other.twitterHandle != null)
                return false;
        } else if (!twitterHandle.equals(other.twitterHandle))
            return false;
        return true;
    }
    @Override
    public String toString() {
        return "Person [firstName=" + firstName + ", lastName=" + lastName + ", title=" + title
               + ", twitterHandle=" + twitterHandle + "]";
    }
}

var persons = Stream.of(new Person(firstName1, lastName1, title1, twitterHandle1),
new Person(firstName2, lastName2, title2, twitterHandle2));

persons.forEach(System.out::println);
```

Records

```
String firstName1 = "Billy";
String lastName1 = "Korando";
String title1 = "Java Developer Advocate";
String twitterHandle1 = "@BillyKorando";

String firstName2 = "Sharat";
String lastName2 = "Chander";
String title2 = "Java Developer Advocate";
String twitterHandle2 = "@Sharat_Chander";

record Person(String firstName, String lastName, String title, String twitterHandle) {}

var persons = Stream.of(new Person(firstName1, lastName1, title1, twitterHandle1),
    new Person(firstName2, lastName2, title2, twitterHandle2));

persons.forEach(System.out::println);
```

Records

- Transparent modeling of data as data
- Superclass always `java.lang.Record`
- Cannot be extend, abstract, and implicitly final
- All fields are final (shallowly immutable)
- Cannot declare instance fields
- Accessors, hashCode, toString, equals, automatically generated
- Can override default implementation, or add your own method definitions

Records

```
String firstName1 = "Billy";
String lastName1 = "Korando";
String title1 = "Java Developer Advocate";
String twitterHandle1 = "@BillyKorando";

String firstName2 = "Sharat";
String lastName2 = "Chander";
String title2 = "Java Developer Advocate";
String twitterHandle2 = "@Sharat_Chander";

record Person(String firstName, String lastName, String title, String twitterHandle) {
    public String toString() {
        return lastName + ", " + firstName +
            " twitter handle: " + twitterHandle +
            " job title: " + title;
    }
}

var persons = Stream.of(new Person(firstName1, lastName1, title1, twitterHandle1),
    new Person(firstName2, lastName2, title2, twitterHandle2));

persons.forEach(System.out::println);
```



Records

```
record Person(String firstName, String lastName, String title, String twitterHandle) {  
    public String toJSON() {  
        return """  
            {"firstName" : "%s",  
             "lastName" : "%s",  
             "title" : "%s",  
             "twitterHandle" : "%s"  
            }  
        """ .formatted(firstName, lastName, title, twitterHandle);  
    }  
}  
  
var persons = Stream.of(new Person(firstName1, lastName1, title1, twitterHandle1),  
    new Person(firstName2, lastName2, title2, twitterHandle2));  
  
persons.forEach(p -> System.out.println(p.toJSON()));
```

Sealed Classes & Records

```
public sealed interface User{  
  
    public record Admin(...) implements User{}  
    public record Guest(...) implements User{}  
    public record Customer(...) implements User{}
```

Code Snippets in Java API Documentation

JDK 18

JEP 413

Code Snippets in Java API Documentation

In-line:

```
/**  
 * The following code shows how to use {@code Optional.isPresent}:  
 * {@snippet :  
 * if (v.isPresent()) {  
 *     System.out.println("v: " + v.get());  
 * }  
 * }  
 */
```

External

```
/**  
 * The following code shows how to use {@code Optional.isPresent}:  
 * {@snippet file="ShowOptional.java" region="example"}  
 */
```

```
public class ShowOptional {  
    void show(Optional<String> v) {  
        // @start region="example"  
        if (v.isPresent()) {  
            System.out.println("v: " + v.get());  
        }  
        // @end  
    }  
}
```

New Runtime Features and Improvements



CDS Updates

JDK 12

Default CDS Archive: JEP 341

JDK 13

Dynamic CDS Archive: JEP 350

AppCDS

```
java -XX:ArchiveClassesAtExit=dynamic-archive.jsa -jar <application>
```

```
java -XX:SharedArchiveFile=dynamic-archive.jsa -jar <application>
```

Z GC

JDK 15 (JEP 377)

- From scratch re-design of GC on Java
- Single generation
- Low Latency (<1 ms pause times)
- Scalable (multi-terabyte heaps)
- Get started: `-XX:+UseZGC -Xmx<size> -Xlog:gc`

Helpful NullPointerExceptions

JDK 14

JEP 358

Helpful NullPointerExceptions

```
Exception in thread "main" java.lang.NullPointerException  
at NPEService.main(NPEService.java:7)
```

```
Exception in thread "main" java.lang.NullPointerException:  
Cannot invoke "String.length()" because "<local1>" is null  
at NPEService.main(NPEService.java:7)
```

AArch64 Support

AArch64 (Arm Arch 64 support)

- Linux JDK 9 (JEP 237)
- Windows JDK 16 (JEP 388)
- macOS JDK 17 (JEP 391)

Simple Web Server

JDK 18

JEP 408

Simple Web Server - Basics

- Start the server: `jwebserver`
- Default server address: `http://127.0.0.1:8000`
- Serve files from current directory
- MIME types automatically configured
 - `.html` rendered as `text/html`
 - `.java` rendered as `text/plain`
- MIME types customizable via: `java.net.URLConnection::getFileNameMap API`

Simple Web Server - Customizations

- `-p` configure port
- `-b` configure binding address
- `-d` for the directory to serve
 - Can be a remote directory
- `-o` configure console output `none|info|verbose` default: `info`
- `-h` to display help, which includes available configuration flags

General Performance Improvements

Spring Boot Petclinic 2.4.5

Requests: 500 (serial)

Heap size: 48 MB

Garbage collector: G1

Java 8 Results (1.8.0_291-b10)

Application startup: 8.665 seconds

Load test execution time: 137 seconds

Java 16 Results (16.0.1+9-24)

Application startup: 6.452 seconds

Load test execution time: 130 seconds

Deprecations Removals And other changes to know about

Deprecations

Security Manager

JDK 17

JEP 411

Applet API

JDK 17

JEP 398

Removals

Nashorn (JavaScript Engine)

JDK 15

JEP 372

CMS Garbage Collector

JDK 14

JEP 363

Other Changes

Strongly Encapsulate JDK Internals

JDK 17

JEP 403

No longer relax strong encapsulation with single argument (i.e. `--illegal-access=permit`)

Some critical internal APIs remain available:

- `sun.misc.{Signal,SignalHandler}`
- `sun.misc.Unsafe` (The functionality of many of the methods in this class is available via *variable handles* ([JEP 193](#))).
- `sun.reflect.Reflection::getCallerClass(int)` (The functionality of this method is available in the stack-walking API defined by [JEP 259](#).)
- `sun.reflect.ReflectionFactory`
- `com.sun.nio.file.{ExtendedCopyOption,ExtendedOpenOption,ExtendedWatchEventModifier,SensitivityWatchEventModifier}`

Strong Encapsulation (cont.)

Eventually --illegal-access=permit will be removed

Can still declare --add-opens to command line and Add-Opens to JAR-Manifest

New Classes, Methods, Fields, etc...

Javadoc New (and Deprecated)

New API since JDK 11

Contents

Modules
Packages
Interfaces
Classes
Enum Classes
Record Classes
Annotation Interfaces
Fields
Methods
Constructors
Enum Constants

(The leftmost tab "New ..." indicates all the new elements, regardless of the releases in which they were added. Each of the other tabs "Added in ..." indicates the new elements added in that release. The tabs are ordered by the release in which they were added.)

New Modules	Added in 16	Added in 14				
Module	Description					
jdk.jpackage	Defines the Java Packaging tool, jpackage.					
jdk.nio.mapmode	Defines JDK-specific file mapping modes.					
New Packages	Added in 17	Added in 14	Added in 12			
Package	Description					
java.lang.constant	Classes and interfaces to represent <i>nominal descriptors</i> for run-time entities such as classes or method handles, and classfile entries.					
java.lang.runtime	The <code>java.lang.runtime</code> package provides low-level runtime support for the Java language.					
java.util.random	This package contains classes and interfaces that support a generic API for random number generation.					
New Interfaces	Added in 17	Added in 16	Added in 15	Added in 14	Added in 13	Added in 12
Interface	Description					
com.sun.source.doctree.SystemPropertyTree	A tree node for an @systemProperty inline tag.					
com.sun.source.tree.BindingPatternTree	A binding pattern tree					
com.sun.source.tree.CaseLabelTree^{PREVIEW}	A marker interface for Trees that may be used as <code>CaseTree</code> labels.					
com.sun.source.tree.DefaultCaseLabelTree^{PREVIEW}	A case label that marks default in case null, default.					

docs.oracle.com/en/java/javase/18-ea/docs/api/new-list.html

The Future



Pattern Matching for Switch

Currently in Preview 2
JEP 420

Pattern Matching for Switch

```
return switch (o) {  
    case Integer i -> String.format("int %d", i);  
    case Long l     -> String.format("long %d", l);  
    case Double d   -> String.format("double %f", d);  
    case String s   -> String.format("String %s", s);  
    default           -> o.toString();  
};
```

Pattern Matching for Switch

```
switch (s) {  
    case Triangle t && (t.calculateArea() > 100) ->  
        System.out.println("Large triangle");  
    case Triangle t ->  
        System.out.println("Small triangle");  
    default ->  
        System.out.println("Non-triangle");  
}
```

Pattern Matching for Switch

```
switch (s) {  
    case null          -> System.out.println("Oops");  
    case "Foo", "Bar"  -> System.out.println("Great");  
    default            -> System.out.println("Ok");  
}
```

Pattern Matching for Switch

```
public sealed interface User{  
  
    public record Admin(...) implements User{}  
    public record Guest(...) implements User{}  
    public record Customer(...) implements User{}  
  
User u = ...  
  
User someUser = switch(u){  
    case Admin a -> ...;  
    case Guest g -> ...;  
    case Customer c -> ...;  
}
```

Pattern Matching for Switch

```
public sealed interface User{  
  
    public record Admin(...) implements User{}  
    public record Guest(...) implements User{}  
    public record Customer(...) implements User{}  
  
User u = ...  
  
switch(u){ //Error not exhaustive!  
    case Admin a -> ...;  
    case Customer c -> ...;  
}
```

Record Patterns and Array Patterns

Currently in candidate status
JEP 405

Record Patterns and Array Patterns

```
record Point(int x, int y) {}
enum Color { RED, GREEN, BLUE }
record ColoredPoint(Point p, Color c) {}
record Rectangle(ColoredPoint upperLeft, ColoredPoint lowerRight) {}

static void printColorOfUpperLeftPoint(Rectangle rectangle) {
    if(rectangle != null){
        ColoredPoint ul = rectangle.ul();
        if (ul != null) {
            Color c = ul.c();
            System.out.println(c);
        }
    }
}
```

Record Patterns and Array Patterns

```
record Point(int x, int y) {}
enum Color { RED, GREEN, BLUE }
record ColoredPoint(Point p, Color c) {}
record Rectangle(ColoredPoint upperLeft, ColoredPoint lowerRight) {}

static void printColorOfUpperLeftPoint(Rectangle rectangle) {
    if(rectangle instanceof Rectangle r){
        ColoredPoint ul = r.ul();
        if (ul != null) {
            Color c = ul.c();
            System.out.println(c);
        }
    }
}
```

Record Patterns and Array Patterns

```
record Point(int x, int y) {}
enum Color { RED, GREEN, BLUE }
record ColoredPoint(Point p, Color c) {}
record Rectangle(ColoredPoint upperLeft, ColoredPoint lowerRight) {}

static void printColorOfUpperLeftPoint(Rectangle rectangle) {
    if(rectangle instanceof Rectangle(ColoredPoint ul, ColoredPoint lr){
        Color c = ul.c();
        System.out.println(c);
    }
}
```

Record Patterns and Array Patterns

```
record Point(int x, int y) {}
enum Color { RED, GREEN, BLUE }
record ColoredPoint(Point p, Color c) {}
record Rectangle(ColoredPoint upperLeft, ColoredPoint lowerRight) {}

static void printColorOfUpperLeftPoint(Rectangle rectangle) {
    if(rectangle instanceof Rectangle(ColoredPoint(p, c), ColoredPoint lr)){
        System.out.println(c);
    }
}
```

Record Patterns and Array Patterns

```
String[] someStrings = new String[]{  
    "foo",  
    "bar"};  
  
if(someStrings instanceof String[]{String s1, String s2}){  
    System.out.println(s1);  
    System.out.println(s2);  
}
```

Record Patterns and Array Patterns

```
String[][] multiDimensionalArray ...  
  
if(multiDimensionalArray instanceof  
    String[][]{{var s1, var s2}, {var s3, var s4}}){  
    ...  
}
```

Record Patterns and Array Patterns

```
record Point(int x, int y) {}
enum Color { RED, GREEN, BLUE }
record ColoredPoint(Point p, Color c) {}
record Rectangle(ColoredPoint upperLeft, ColoredPoint lowerRight) {}

static void printColorOfUpperLeftPoint(Rectangle rectangle) {
    if(rectangle instanceof Rectangle(ColoredPoint(Point p, Color c), ColoredPoint lr){
        System.out.println(c);
    }
}
```

Early Access Builds

<https://jdk.java.net/18/>

<https://jdk.java.net/loom/>

<https://jdk.java.net/panama/>

<https://jdk.java.net/valhalla/>

Links and Code Examples

Slide deck: <https://github.com/wkorando/to-java-17-and-beyond>

<https://openjdk.java.net/jeps/0>

<https://jdk.java.net/17/release-notes>

<https://github.com/wkorando/sip-of-java>

<https://wkorando.github.io/sip-of-java/>

<https://carlmastrangelo.com/blog/the-impossible-java-11>

Thank you

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