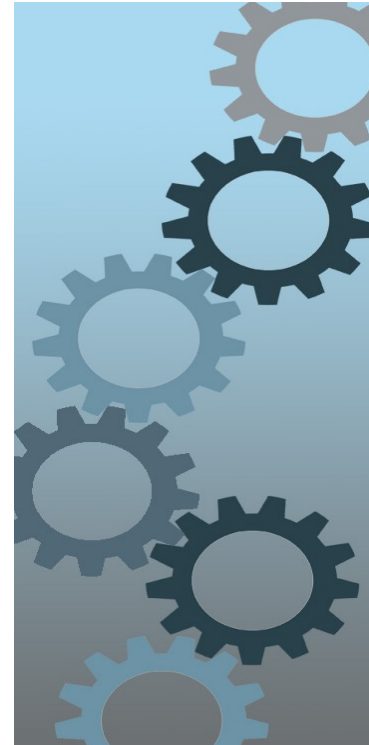


Programming Concepts And Paradigms

Loom, Structured Concurrency
and other
New Concepts

Marcel Baumann



Content

- NIO and NIO.2
- Local Date and Time
- Auto Closeable *java.lang.AutoCloseable*
- javax.measure
- Project Loom
- Project Valhalla
- Project Amber

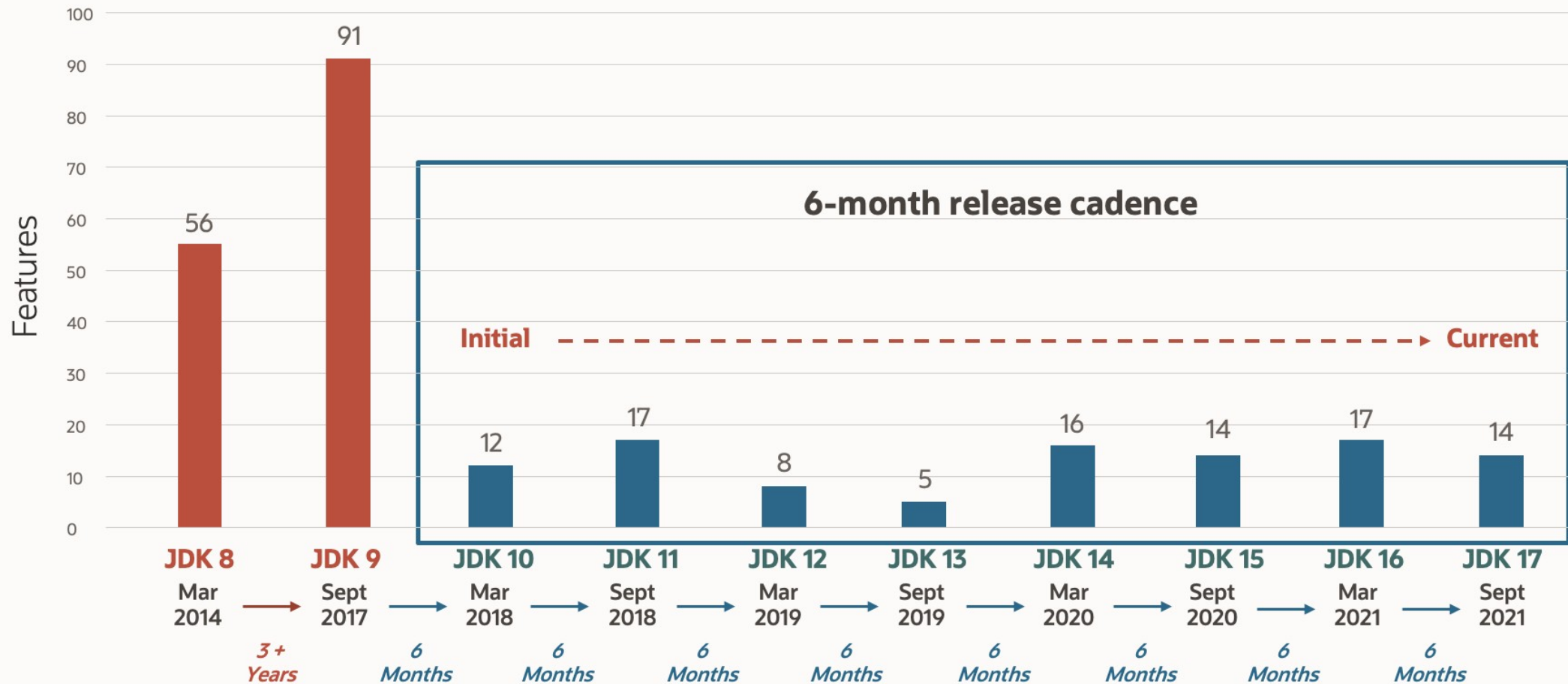
Java Ecosystem



GraalVM™

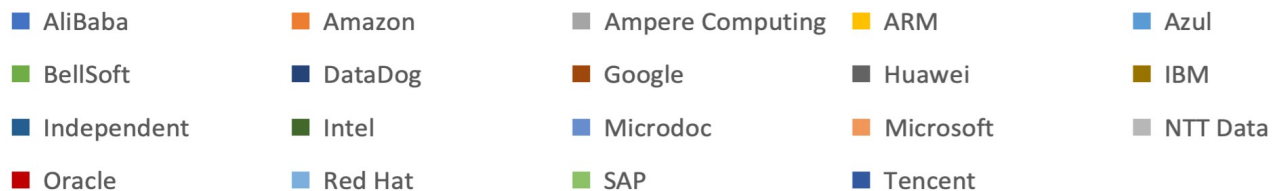


Java Releases



Open Source Effort

Issues fixed in JDK 16 per organization



New Input Output NIO and NIO.2

- Design error with *java.io.File*
 - *Does not support file system abstraction*
- Correction with *java.nio.file.Path*
- Provides Files and Paths utility class
- Huge improvement with FileSystem concept

Stream Oriented Functions

```
public static Stream<Path> walk(Path start,  
    int maxDepth,  
    FileVisitOption... options)throws IOException  
  
public static Stream<Path> find(Path start,  
    int maxDepth,  
    BiPredicate<Path, BasicFileAttributes> matcher,  
    FileVisitOption... options) throws IOException  
  
public static Stream<String> lines(Path path,  
    Charset cs) throws IOException
```

Date and Time

- History
 - One of the worst class *java.util.Date*
 - Why did they invent *java.sql.Date*?
 - Save the world: Joda library
- Correctness through *java.time* package
 - **Immutable instances**
 - **Date operations**

Date and Time

- Instant
- LocalTime
- LocalDate
- LocalDateTime
- ZonedDateTime
- *(Year, YearMonth, DayOfWeek, Clock)*
- *(java.time.chrono → Generic API for calendar systems other than the default ISO.)*

java.time

- *Instant* is a timestamp
- *LocalDate* is a date without a time, or any reference to an offset or time-zone
- *LocalTime* is a time without a date, or any reference to an offset or time-zone
- Composition
 - *LocalDateTime* combines date and time, but still without any offset or time-zone
 - *ZonedDateTime* is a "full" date-time with time-zone and resolved offset from UTC/Greenwich
 - *OffsetTime*, *ZonedDateTime* and *ZoneOffset*, *Year* and *YearMonth*
 - *Period* is a time-based amount of time, such as '34.5 seconds'.

AutoCloseable

- Finalizers are obsolete (*JEP 421 deprecate Finalization for Removal in JDK 18*)
 - They are a design error because they cannot be implemented efficiently with garbage collectors
- AutoCloseable and try with resources
 - Compatibility by updating Closeable
Closeable implements AutoCloseable
 - Compiler eliminates verbosity and programmer's errors
 - Mix API and language extension

Text Blocks & Formatting

- Readable text constants

```
""""  
    ....  
""""
```

- Formatting

```
return """"  
  
    LegalEntity[oid=%s, id=%s, name=%s, fromDate=%s, toDate=%s, text=%s, vatNr=%s, tags=%s]  
  
    """.formatted(oid(), id(), name(), fromDate(), toDate(), text(), vatNr(), tags());
```

Modern equals()

```
class T {  
    ...  
    @Override  
    public boolean equals(Object obj) {  
        return (obj instanceof T that) &&  
            (Objects.equals(x, that.x) && ...;  
    }  
}
```

Modern toString()

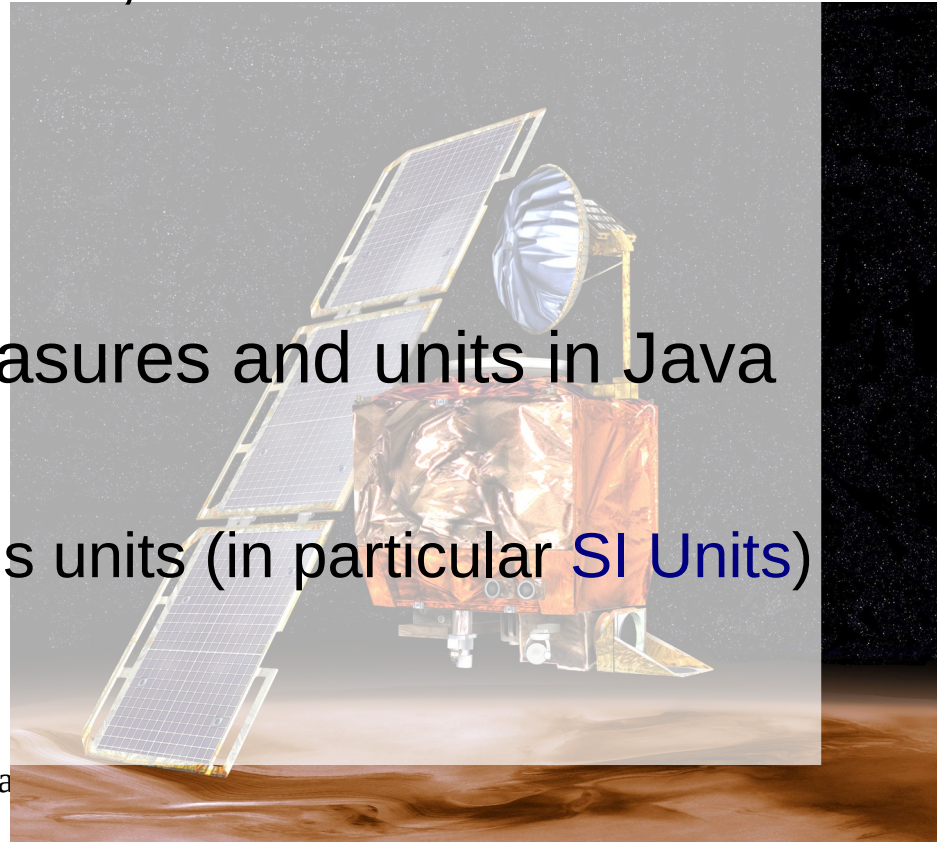
```
class T {  
    ...  
    @Override  
    public String toString() {  
        return ""  
            Activity[date=%s, code=%s]  
            "".formatted(date(), code());  
    }  
}
```

Control Questions

1. Why was the *java.util.Date* class not removed?
2. How can you discourage developer to use a class or a method in Java?

jvax.measure

- JSR-385 *API 2.0* (JSR-363 *API 1.0*, JSR-275 *Unit Specifications*)
 - jvax.measure:unit-api:2.1.3
 - tec.units:indriya:2.1.3
- Unified way of representing measures and units in Java
 - Checking of unit compatibility
 - Expression of a quantity in various units (in particular **SI Units**)
 - Arithmetic operations on units



javax.measure

```
double distanceInMeters = 50.0;
```

```
UnitConverter metreToKilometre =  
    METRE.getConverterTo(MetricPrefix.KILO(METRE));
```

```
double distanceInKilometers =  
    metreToKilometre.convert(distanceInMeters );
```

Loom

- Virtual threads (JEP 425)
- Delimited continuations
- Tail-call elimination
- *All three features are available in Scheme (also in Clojure) for decades ;-)*
- *Virtual threads exist in Smalltalk, Erlang, Go, etc.*



Loom

```
Thread thread = Thread.startVirtualThread(runnable);  
ExecutorService executor = Executors.newVirtualThreadExector();  
  
executor.submit(runnable);  
executor.submit(callable);
```

Structured Concurrency

- Synchronization Tools

- Fork And Join

- Future

- ExecutorService

- `<T> List<Future<T>> invokeAll(Collection<? extends Callable<T>> tasks, long timeout, TimeUnit unit)` throws `InterruptedException`

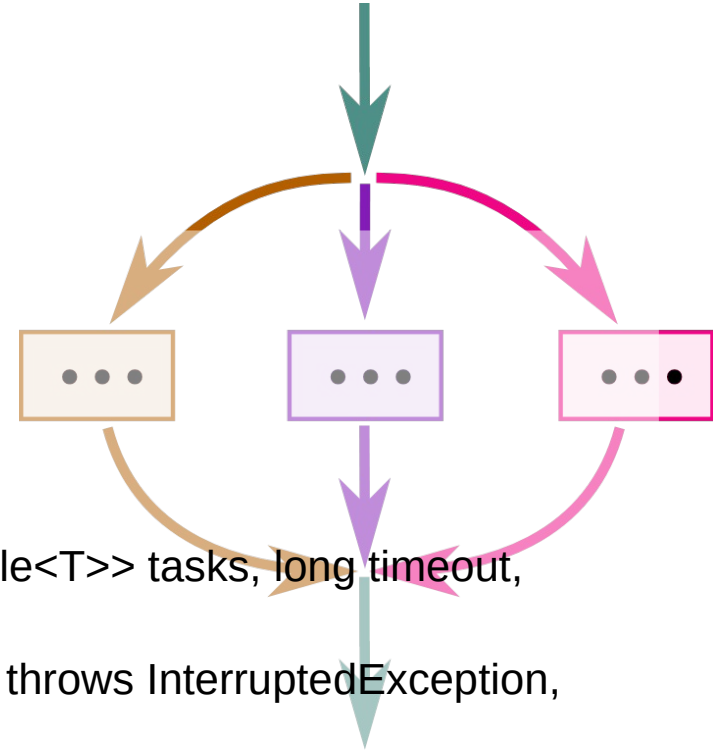
- `<T> T invokeAny(Collection<? extends Callable<T>> tasks)` throws `InterruptedException`, `ExecutionException`

- CompletableFuture

- The goal is

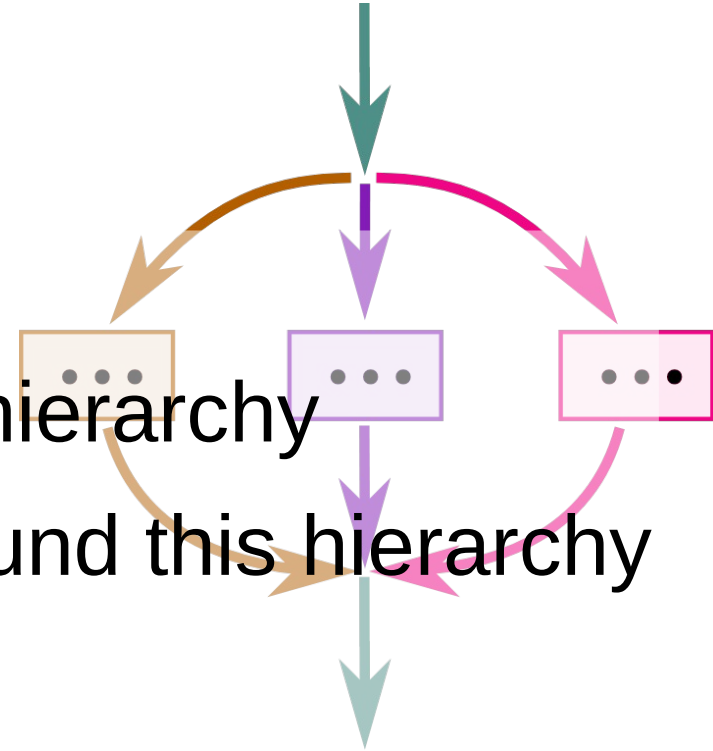
- No complex synchronization to wait for completion

- Follow the flow of the program, do not create a new flow (see for example `async` for a new flow with rules such as only `async` calls)



Structured Concurrency

- Bind thread lifetime to a scope
- Interpret this as a parent – child hierarchy
- Build programming concepts around this hierarchy



Structured Concurrency

```
var NTASKS = 1000;

try (ExecutorService exec = Executors.newVirtualThreadExecutor()) {
    for (int i = 0; i < NTASKS; i++) {
        exec.submit(() -> {
            try { TimeUnit.SECONDS.sleep(1); }
            catch (InterruptedException e) {}
        })
    }
}

// Blocks until all threads completed,
// ExecutorService implements AutoClosable
```

```
ExecutorService exec =
Executors.newVirtualThreadExecutor().withDeadline(
    Instant.now().plus(30, ChronoUnit.SECONDS));
```

```
CompletableFuture<Integer> future = exec.submitTask(callable);
```

Loom Next Steps (JDK 19)

- Virtual Threads ([JEP 425](#)) delivers virtual threads to Java and JVM
 - Build on the following JEP
 - [JEP 416](#) (Reimplement Core Reflection with Method Handles) in JDK 18 removed the VM-native reflection implementation. This allows virtual threads to park gracefully when methods are invoked reflectively.
 - [JEP 353](#) (Reimplement the Legacy Socket API) in JDK 13, and [JEP 373](#) (Reimplement the Legacy DatagramSocket API) in JDK 15, replaced the implementations of `java.net.Socket`, `ServerSocket`, and `DatagramSocket` with new implementations designed for use with virtual threads.
 - [JEP 418](#) (Internet-Address Resolution SPI) in JDK 18 defined a service-provider interface for host name and address lookup. This will allow third-party libraries to implement alternative *java.net.InetAddress* resolvers that do not pin threads during host lookup.

Valhalla

- Numeric Type System Unification → everything is an object
- But not all objects have an identity
 - So the object does no more follow object-oriented axioms of: *state, identity and behavior*

Valhalla Steps

- Warning for value based class
 - Do not use constructors for value based classes such as Boolean, Byte, Short, Character, Integer, Long, Float, Double.
 - Value classes are marked with *@jdk.internal.ValueBased* annotation
 - Warning if you synchronize *synchronized* on an instance of such a class. Anyway stop using *synchronized* and move to concurrency package.

Valhalla Next Steps

- Primitive Objects (JEP 401)
 - primitive class Point implements Shape { ... }
 - *Implicit final class with implicit final instance variables → immutable objects*
 - *== on fields equality and not on object equality*
- Unify Basic Primitives with Objects (JEP 402)
 - int and Integer will be the same

Graal VM

- Polyglot environment
 - Seamlessly use multiple languages and libraries
 - Support to compile own language
- Self-hosted Java
- Ahead of Time Compilation AOT (*next try*)
 - Increase application throughput and reduce latency
 - Compile applications into small self-contained native binaries

REPL in Java: Jshell & JBang

- Support of **exploratory programming**
 - REPL is a tool to test interactively small programs. Jshell was introduced in JDK 9
 - Embedded **Web Server** is a tool to test small web programs in JDK 18

REPL in Java: Jshell Demonstration

Lombok Approach

- Annotation approach
 - @Data
 - @Value
 - @With
 - @Builder, @SuperBuilder
 - @Getter, @Setter, @Log
 - @Accessors

Amber

- *Records and Sealed Types*
- *Pattern matching for **instanceof** in if*
- Pattern matching for switch statements
- Deconstruction of records and arrays
- Concise method body

Guarded Pattern With switch

```
static void test(Object o) {  
    switch (o) {  
        case String s when (s.length() == 1) -> ...  
        case String s -> ...  
    }  
}
```


Pattern Matching With if and switch

```
if ((obj instanceof String s) && (s.length() > 5)) {  
    flag = s.contains("jdk");  
}
```

```
String formatted = 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 Record

```
static void printXCoordOfUpperLeftPointWithPatterns(  
    Rectangle r) {  
    if (r instanceof Rectangle(ColoredPoint(  
        Point(var x, var y), var c), var lr)) {  
        System.out.println("Upper-left corner: " + x);  
    }  
}
```

Pattern Matching Arrays

```
static void printSumOfFirstTwoXCoords(Object o) {  
    if (o instanceof Point[] { Point(var x1, var y1),  
Point(var x2, var y2), ... }) {  
        System.out.println(x1 + x2);  
    }  
}
```

Control Questions

1. What is a virtual (also called green) thread?
2. What is the meaning of tail-call optimization?
3. What is a deconstruction pattern

Exercises

- Implements toString, equals, hashCode and Comparable
- javax.measure example