

# Java 21

## add sparkle to your life

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Don't believe what I'm saying !

# Plan

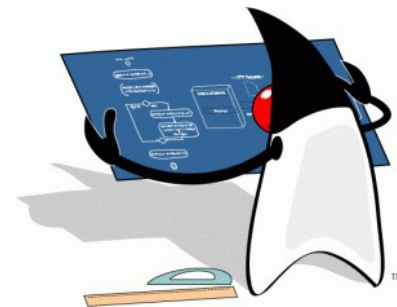
# Language Changes

- Unnamed class (preview)
- Pattern Matching : instanceof + switch + record pattern
- Template Processor (preview)

# API Changes

- Sequenced Collection
- Virtual Threads
- Structured Concurrency (preview)

# Platform integrity



# Java enboarding



# What if ?

Before

```
public class Main {  
    public static void main(String[] args) {  
        System.out.println("Java is cool !");  
    }  
}
```

After

```
void main() {  
    System.out.println("Java is cooler !");  
}
```

# JEP 445 : Unnamed class (preview)

There are 3 levels of encapsulation in Java

Class < Package < Module

We have unnamed module and unnamed package

- we are adding unnamed class

Methods without an enclosing class are encapsulated into a top-level class with a name derived from the filename (minus .java)

# JEP 445: ... + instance main methods

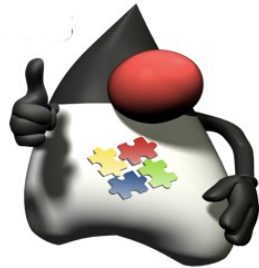
## Change the launcher protocol

- Look for
  - `static void main(String[])` or `static void main()`
  - `void main(String[])` or `void main()`
- If `main()` is an instance method, the constructor with no parameter is called first

DEMO !



# Pattern Matching



# Open Types vs Closed Types

In libraries, we want the types to be **open** so users can implement them

In applications, we want types to be **closed** so developers knows all possible subtypes

This is almost always true

# Open aka non-sealed Type

MilitaryUnit = Soldier | Carrier | ...

```
/*non-sealed*/ interface MilitaryUnit {  
    int firepower();  
}
```

```
record Soldier(String name, int firepower) implements MilitaryUnit {}
```

```
record Carrier(List<MilitaryUnit> units) implements MilitaryUnit {  
    public int firepower() {  
        return units.stream()  
            .mapToInt(u -> u.firepower())  
            .sum();  
    }  
}
```

# Sealed Type

MilitaryUnit = Soldier | Carrier

```
sealed interface MilitaryUnit { }
```

```
record Soldier(String name, int firepower) implements MilitaryUnit { }
```

```
record Carrier(List<MilitaryUnit> units) implements MilitaryUnit { }
```



A good interface is an empty interface

# Sealed Type operation

```
int firepower(MilitaryUnit unit) {  
    if (unit instanceof Soldier soldier) {  
        return soldier.firepower();  
    }  
    if (unit instanceof Carrier carrier) {  
        return carrier.units().stream()  
            .mapToInt(u -> firepower(u))  
            .sum();  
    }  
    throw new MatchException("oops", null);  
}
```

instanceof in Java 17

not typesafe !

new in Java 21 !

# Pattern Matching / switch on type

```
int firepower(MilitaryUnit unit) {  
    return switch(unit) {  
        case Soldier soldier -> soldier.firepower();  
        case Carrier carrier -> carrier.units().stream()  
            .mapToInt(u -> firepower(u))  
            .sum();  
    };  
}
```

Switch on type – new in Java 21

Will not compile if new subtypes !

No default !

# Record Patterns

```
int firepower(MilitaryUnit unit) {  
    return switch(unit) {  
        case Soldier(String name, int firepower) -> firepower;  
        case Carrier(List<MilitaryUnit> units) -> units.stream()  
            .mapToInt(u -> firepower(u))  
            .sum();  
    };  
}
```

Will not compile if a data definition change !

# Var Pattern

```
int firepower(MilitaryUnit unit) {  
    return switch(unit) {  
        case Soldier(var name, var firepower) -> firepower;  
        case Carrier(var units) -> units.stream()  
            .mapToInt(u -> firepower(u))  
            .sum();  
    };  
}
```

Let the compiler infer the types



# Unnamed Variable (preview)

```
int firepower(MilitaryUnit unit) {  
    return switch(unit) {  
        case Soldier(var   , var firepower) -> firepower;  
        case Carrier(var units) -> units.stream()  
            .mapToInt(u -> firepower(u))  
            .sum();  
    };  
}
```

Use '  ' as a variable name (everywhere but in API)

# Unnamed Pattern (preview)

```
int firepower(MilitaryUnit unit) {  
    return switch(unit) {  
        case Soldier(_, var firepower) -> firepower;  
        case Carrier(var units) -> units.stream()  
            .mapToInt(u -> firepower(u))  
            .sum();  
    };  
}
```

Using '\_' as pattern

# Data Oriented Programming

Sealed Types + Pattern matching enables DOP

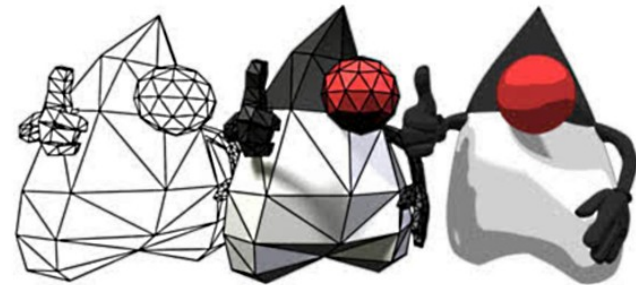
Switch on types / instance of

- Type pattern
- Record pattern
- Var pattern
- Unnamed pattern

Data definition is more  
important than code



# String Template Processor



# STR (preview)

```
var joe = new Soldier("Joe", 200);  
var jane = new Soldier("Jane", 200);  
var carrier = new Carrier(List.of(joe, jane));  
System.out.println(STR.``  
    Jane firepower:  \{ firepower(jane) \}  
    carrier firepower: \{ firepower(carrier) \}  
    ``");
```

STR is auto-imported

String interpolation !



# FMT (preview)

C-like formatting



```
var joe = new Soldier("Joe", 200);  
var jane = new Soldier("Jane", 200);  
var carrier = new Carrier(List.of(joe, jane));  
System.out.println(FMT."  
    Jane firepower:    %04d\{ firepower(jane) }  
    carrier firepower: %04d\{ firepower(carrier) }  
    """);
```

FMT requires an import static java.util.FormatProcessor.FMT

# My own TemplateProcessor (preview)

```
StringTemplate.Processor<String, RuntimeException> fireProcessor =  
    (StringTemplate templatedString) -> {  
        List<String> fragments = templatedString.fragments();  
        List<Object> values = templatedString.values();  
        System.out.println(STR."fragments:\{ fragments } values:\{ values }");  
        ...  
    };  
System.out.println(fireProcessor.""  
    Jane firepower:  \{ jane }  
    carrier firepower: \{ carrier }  
    """);
```



A StringTemplate is a text  
separated by values

# My own TemplateProcessor (2/2)

```
StringTemplate.Processor<String, RuntimeException> fireProcessor =  
    (StringTemplate t) -> {  
        return StringTemplate.interpolate(t.fragments(), t.values().stream()  
            .map(value -> firepower((MilitaryUnit) value))  
            .toList());  
    };  
};
```

```
System.out.println(fireProcessor.``````  
    Jane firepower:  \{ jane }  
    carrier firepower: \{ carrier }  
    ``````);
```



No way to type the values :(



# Performance :(

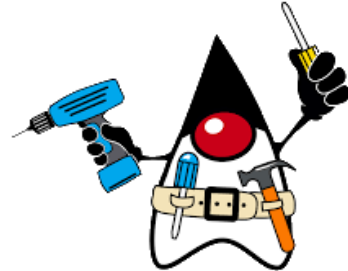
```
public String concat() {  
    var message = "string template";  
    return "hello " + message + " !";  
}
```

```
public String with_STR() {  
    var message = "string template";  
    return STR."hello \{message} !";  
}
```

```
static final StringTemplate.Processor<String, RuntimeException> STR_INTERPOLATE =  
    StringTemplate::interpolate;  
public String with_interpolate() {  
    var message = "string template";  
    return STR_INTERPOLATE."hello \{message} !";  
}
```

	score $\pm$ error
concat	5.042 $\pm$ 0.137 ns/op
with_STR	5.037 $\pm$ 0.111 ns/op
with_interpolate	12.509 $\pm$ 0.049 ns/op

# Sequenced Collections



# Goals

## Add useful methods

- `List.getFirst() / getLast()`
- `for(var item : list.reversed()) { ... }`
- `LinkedHashSet.getFirst() / getLast()`
- `for(var item : linkedHashSet.reversed()) { ... }`

# SequencedCollection

Collection with an order (insertion, sorted, access?)

Added methods :

- `getFirst()/getLast()`
- `addFirst/addLast/removeFirst()/removeLast()`
- `SequencedCollection reversed()`



This is a view !

# Example

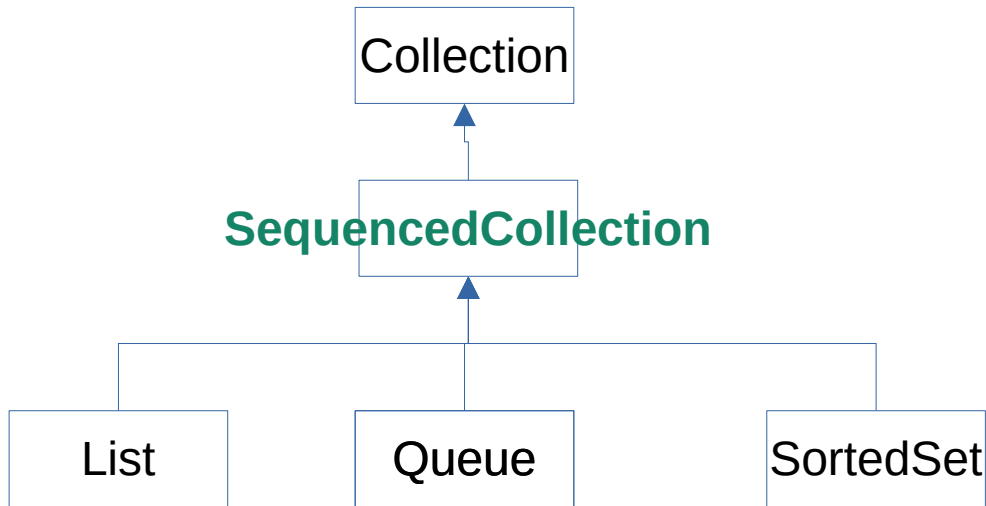
```
var joe = new Soldier("Joe", 200);  
var jane = new Soldier("Jane", 200);  
var carrier = new Carrier(List.of(joe, jane));  
  
System.out.println("first " + carrier.units().getFirst());  
System.out.println("last " + carrier.units().getLast());  
for (var unit: carrier.units().reversed()) {  
    System.out.println("unit " + unit);  
}
```



for loop in reverse order

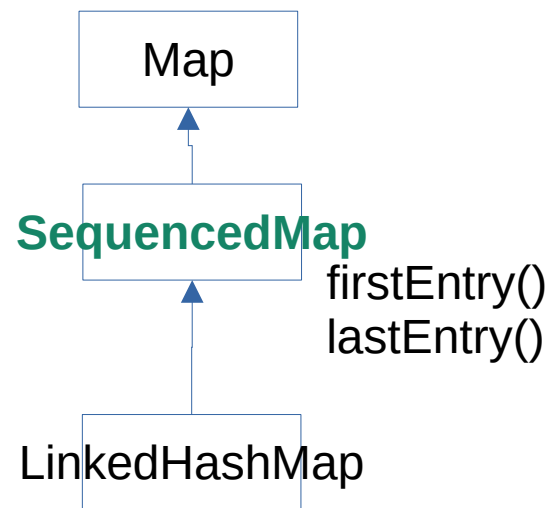
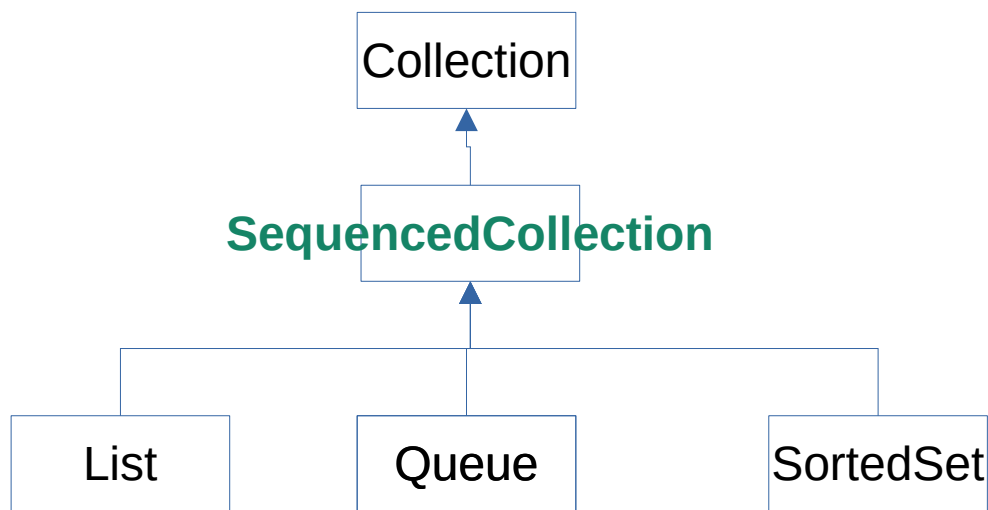
# Hierarchy (v1)

SequencedCollection is a supertype of List, Queue and SortedSet



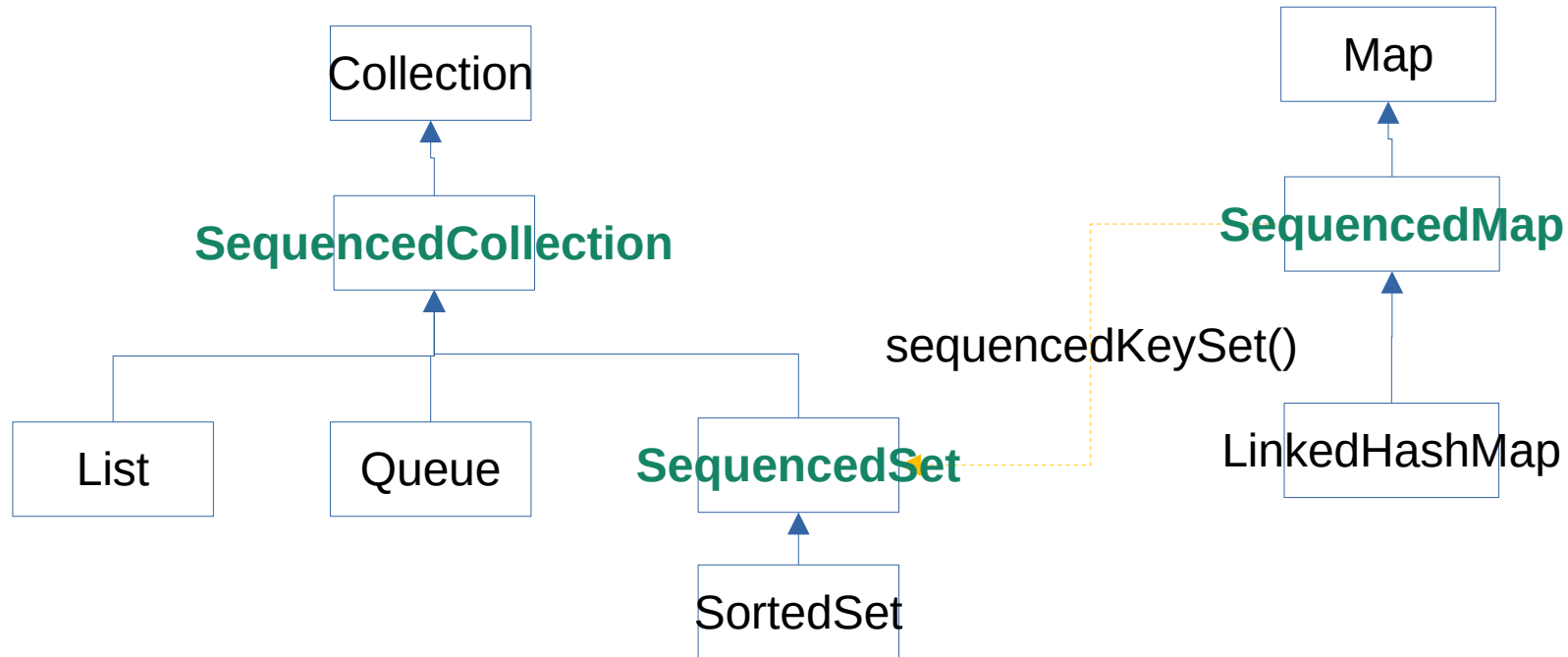
# Hierarchy (v1) + Map

We want LinkedHashMap to be SequencedMap ?



# Hierarchy (v2)

We need a SequencedSet to type SequencedMap.keySet()





# Beware ! Here be dragons

## Worst Case Complexity

List.addFirst()/removeFirst() are in  $O(n)$

reverse ordered by access

## LinkedHashMap is weird

```
var map = new LinkedHashMap<>(0, 0.75f, true);  
map.put("foo", 3);  
map.put("bar", 42);
```

```
System.out.println(map.get("foo")); // 3  
System.out.println(map.firstEntry()); // bar = 42
```



# Virtual Threads



# History

In C during the 80s

- OS processus + OS lock

In C during the 90s

- OS thread + mutex (application lock)

In Java during the 90s

- OS thread + synchronized (application lock)

# Project Loom

Write synchronous code, execute asynchronously

Java 21: Application thread + application lock

Java can schedule millions of application threads (virtual threads) on top of few OS threads (# of cores)

# How it works ?

When a method that should block is called

- The virtual thread is unmounted
  - The stack is copied to the heap
- A handler is registered on the blocking event

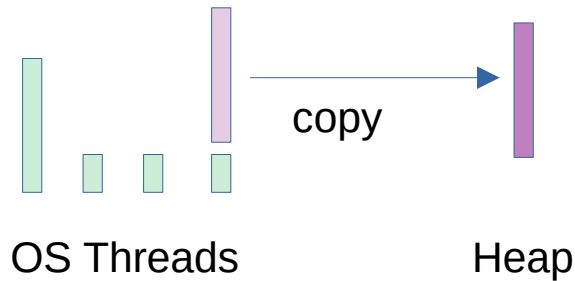
When the event handler is called

- The virtual thread can be scheduled (a fork/join pool in FIFO mode)
  - When scheduled, the virtual thread is mounted
    - The stack is copied back (incrementally)

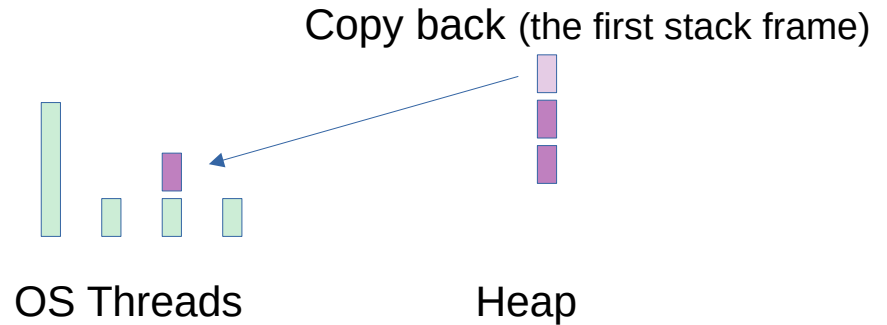
# Mount and unmount

The VM copies parts of the stack back and forth

unmount

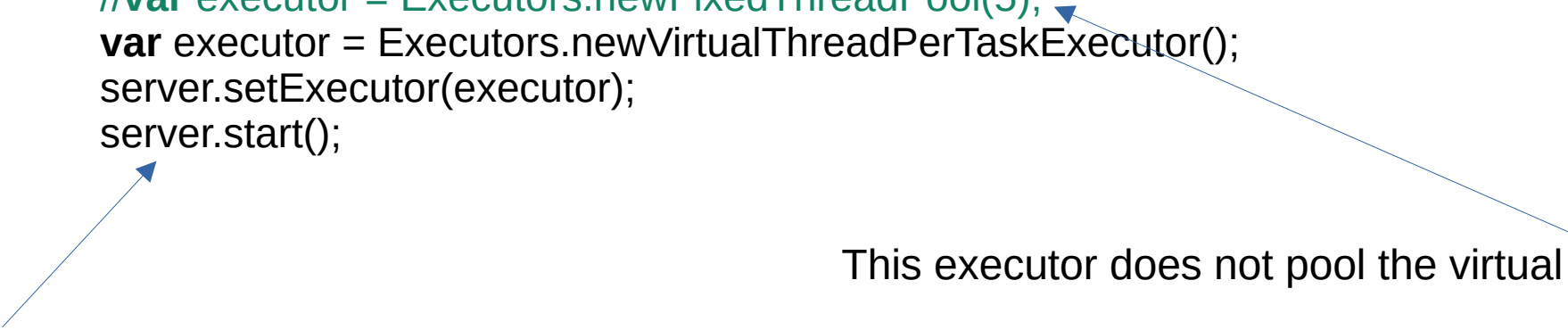


mount



# jwebserver example

```
var path = Path.of("src/main/java").toAbsolutePath();  
var handler = SimpleFileServer.createFileHandler(path);  
var logger = SimpleFileServer.createOutputFilter(System.out, OutputLevel.INFO);  
var server = HttpServer.create(new InetSocketAddress(8080), 10, "/", handler, logger);  
//var executor = Executors.newFixedThreadPool(5);  
var executor = Executors.newVirtualThreadPerTaskExecutor();  
server.setExecutor(executor);  
server.start();
```



Command line

jwebserver [-b bind address] [-p port] [-d directory]

This executor does not pool the virtual threads

# Main Limitation

Synchronized blocks are implemented by storing a pointer to the stack

- Problem if there is a blocking call inside a synchronized
  - The virtual thread can not be unmounted (pined)
    - Use ReentrantLock instead
  - There are two OpenJDK projects to rewrite the synchronized implementation



# Can I use virtual threads now ?

Virtual threads are supported by

- Spring 6.1
- Quarkus 3 with `@RunOnVirtualThread`, Micronaut 4 with `@Executes(BLOCKING)`,
- Helidon 4 (Mina) Q4 2023

## Servers

- Tomcat, Jetty
- Netty has no support !?!

## DB Drivers

- Postgres, H2, Oracle 21c

# Structured Concurrency



# Structured Concurrency (preview)

A better API than Executor / Future

```
try (var scope = new StructuredTaskScope<Integer>()) {  
    var task1 = scope.fork(() -> ...);  
    var task2 = scope.fork(() -> ...);  
    scope.join();  
    var result1 = task1.get();  
    var result2 = task2.get();  
}
```

▲ No runaway threads anymore ?

# Shutdown On Failure

Model serial groups of concurrent tasks

```
try (var scope = new StructuredTaskScope.ShutdownOnFailure<Integer>()) {  
    var task1 = scope.fork(() - > ...);  
    var task2 = scope.fork(() - > ...);  
    scope.join();  
    var task3 = scope.fork(() - > ...);  
    scope.join();  
    scope.throwIfFailed();  
    .. task1.get() .. task2.get() .. task3.get()  
}
```

group 1

group 2

# Streamable (Java 22 ?)

Specify the business code on a stream of tasks

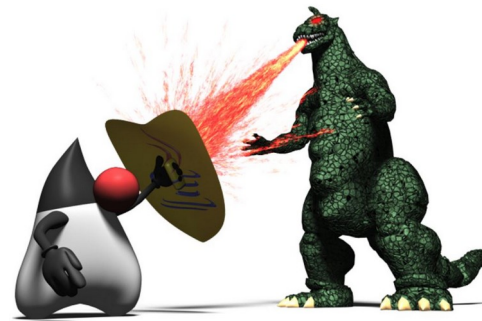
```
try (var scope = new StructuredTaskScope.Streamable<Integer>()) {  
    scope.fork(() -> ...);  
    scope.fork(() -> ...);  
    List<Task<Integer>> list = scope.joinWhile(Stream::toList);  
    System.out.println(list)  
}
```

# Streamable + limit + groupBy

If the stream is short-circuited, the remaining tasks are cancelled

```
try (var scope = new StructuredTaskScope.Streamable<Integer>()) {  
    scope.fork(() - > ...);  
    ...  
    Map<State, Task<Integer>> map =  
        scope.joinWhile(s - > s.limit(3).collect(groupingBy(Subtask::getState)));  
    System.out.println(map.get(State.SUCCESS));  
}
```

# Platform Integrity



# OpenJDK Integrity

Java 9 : Module enforces integrity

- No access to OpenJDK internals  
and `setAccessible(true)` is disabled on OpenJDK code

Make Loom development faster

- reflection implementation changed
- Socket and Channel implementations changed
- etc ...



# Integrity by default (1/2)

Extends the notion of integrity

<https://openjdk.org/jeps/8305968>

Dynamic agents, JNI and Foreign Function & Memory

Prepare to Disallow dynamic Loading of Agents (JEP 451)

- No problem if -javaagent or Launcher-Agent-Class
- Warning in Java 21
  - Error in the future, use -XX:+EnableDynamicAgentLoading

# Integrity by default (2/2)

## Foreign Function & Memory API (JEP 454)

- When calling a C function or allow unbounded access to native memory

`--enable-native-access=module` or `Enable-Native-Access`

## Prepare to restrict use of JNI

<https://openjdk.org/jeps/8307341>

also use `--enable-native-access`

I would like to hear your opinion ?

# Executive Summary



# Java 21

Java 21 focused on application developers

- Pattern Matching : instanceof + switch + record pattern
- Virtual Threads
- Sequenced Collection

with an eye to the future

- Unnamed class (preview)
- Template Processor (preview)
- Structured Concurrency (preview)

