

Java 21

add sparkle to your life

Rémi Forax
Université Gustave Eiffel – Sept 2023



CALVIN & HOBBS © BIL WATTERSON

Don't believe what I'm saying !

Plan

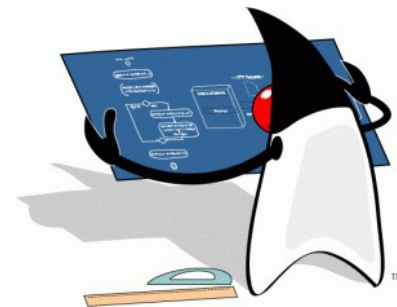
Language Changes

- 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)

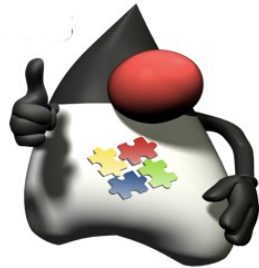
JEP 445: ... + instance main methods

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

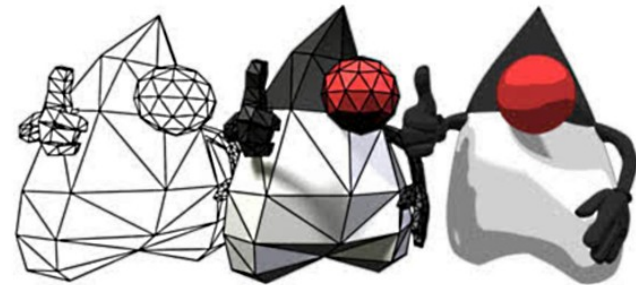
Switch on types / instanceof

- 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)

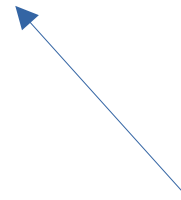
```
StringTemplate.Processor<String, RuntimeException> fireProcessor =  
    (StringTemplate templatedString) -> {  
        List<String> fragments = templatedString.fragments();  
        List<Object> values = templatedString.values();  
        System.out.println(STR."fragments:\{ fragments } values:\{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

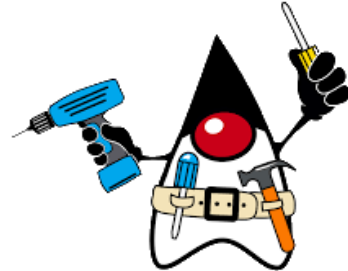
```
public String with_STR() {
 var message = "string template";
 return STR."hello \{message} !";
}
```

```
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));

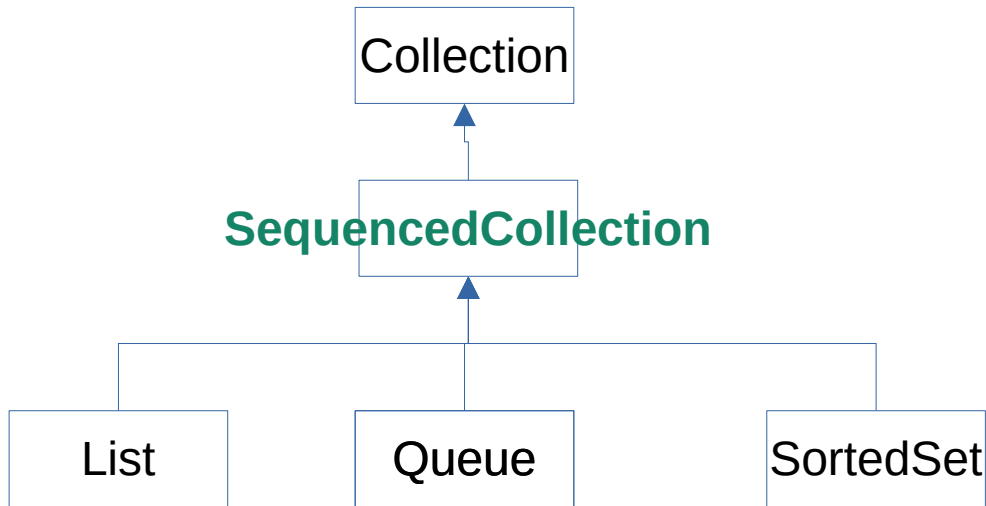
System.out.println("first " + carrier.units().getFirst());
System.out.println("last " + carrier.units().getLast());
for (var unit: carrier.units().reversed()) {
 System.out.println("unit " + unit);
}
```



for loop in reverse order

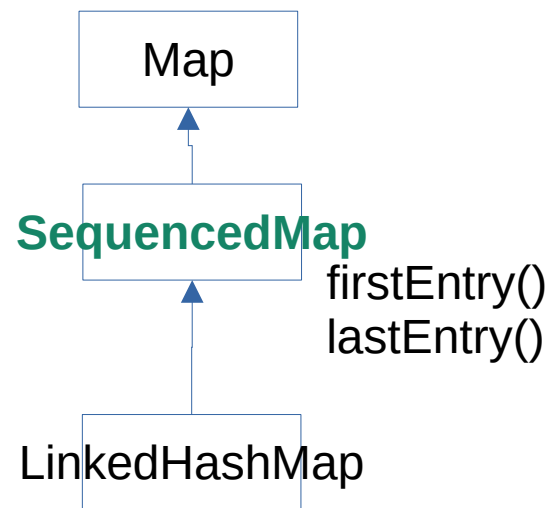
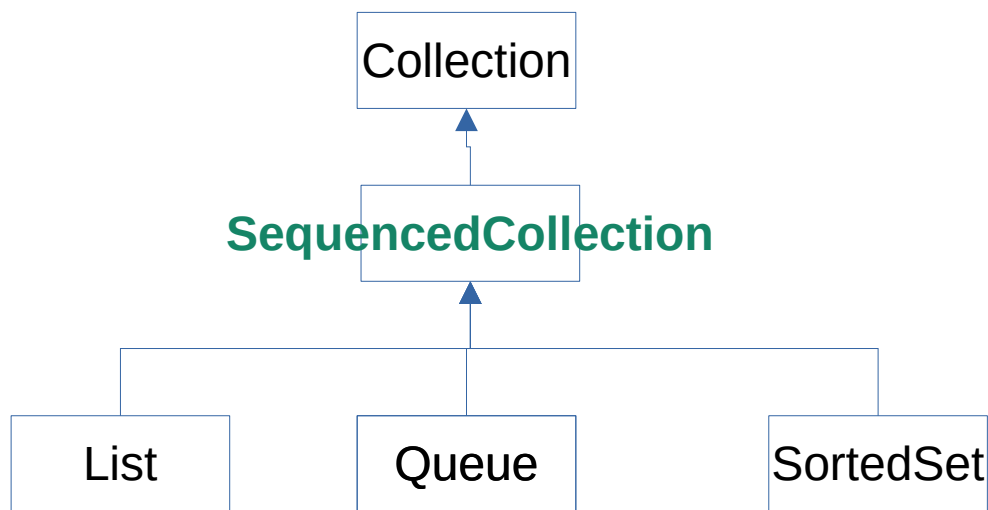
# Hierarchy (v1)

SequencedCollection is a supertype of List, Queue and SortedSet



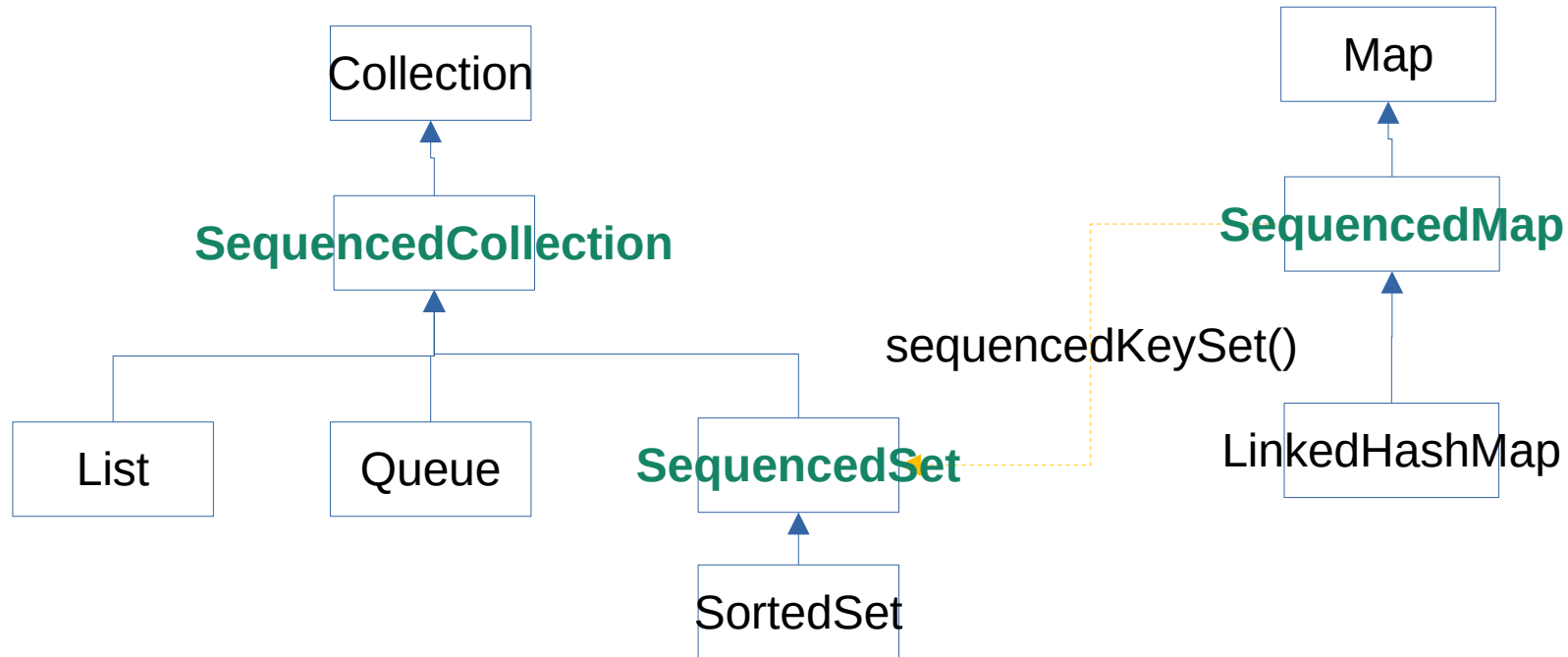
# Hierarchy (v1) + Map

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

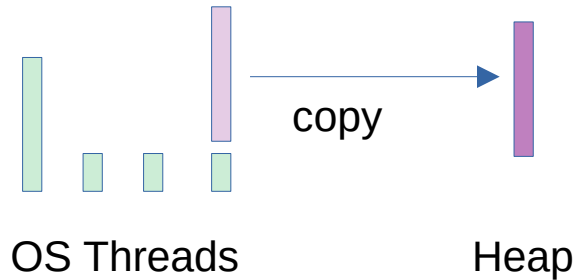
When the event handler is called

- 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)

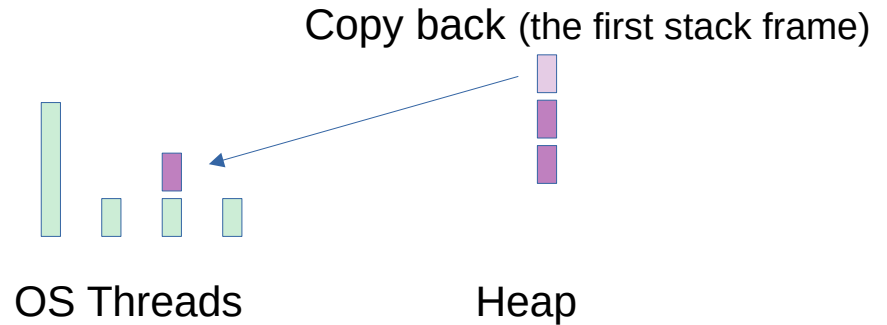
# Mount and unmount

The VM copies parts of the stack back and forth

unmount

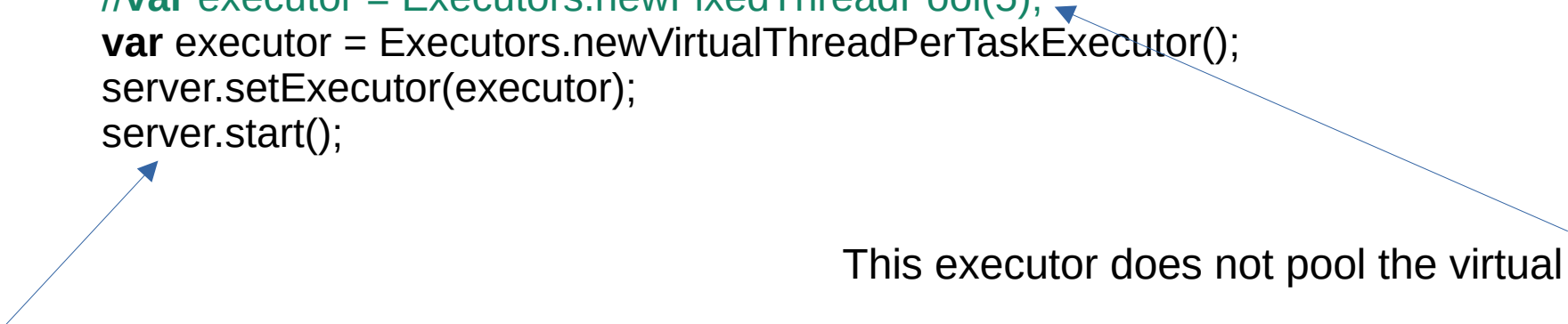


mount



# 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();
```

A diagram with two blue arrows. One arrow originates from the text 'Command line' and points to the 'server.start()' line in the code. The other arrow originates from the text 'This executor does not pool the virtual threads' and points to the line '//var executor = Executors.newFixedThreadPool(5);'.

Command line

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

This executor does not pool the virtual threads

# 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

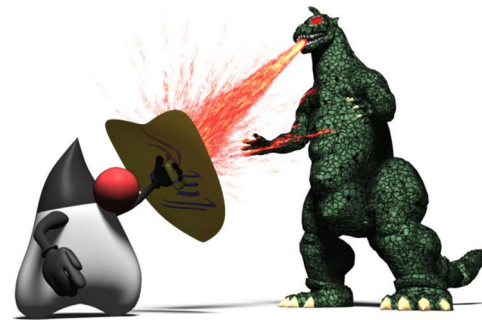
```
try (var scope = new StructuredTaskScope.Streamable<Integer>()) {
 scope.fork(() -> ...);
 scope.fork(() -> ...);
 List<Task<Integer>> list = scope.joinWhile(Stream::toList);
 System.out.println(list)
}
```

# 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)

