🏋️ Refactoring sans les `for`

Igor Laborie

Expert Web & Java

@ilaborie <https://twitter.com/ilaborie>

igor@monkeypatch.io <mailto:igor@monkeypatch.io>

<Monkey Patch/>

Plan

I. Introduction
II. Anatomie d'une boucle
III. Récursion
IV. `Stream`
V. Qui est le meilleur ?
VI. Conclusion

#backToBasics

> *Les frameworks et bibliothèques naissent et meurent, les bases restent.*

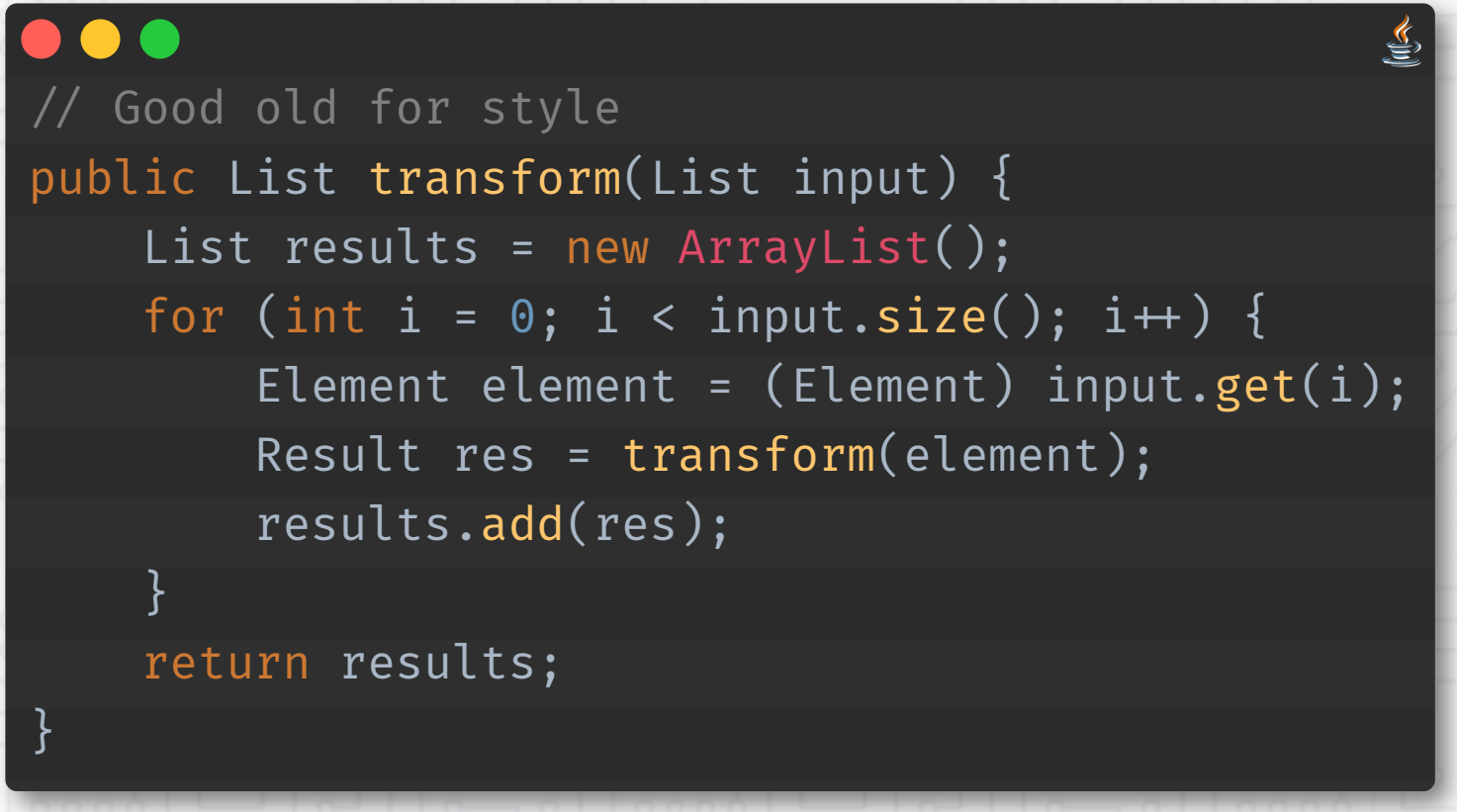
Existe-il des langages de programmation sans `for` ?

Haskell
Scala *
Erlang

Clojure *
Assembleur
ByteCode Java
...

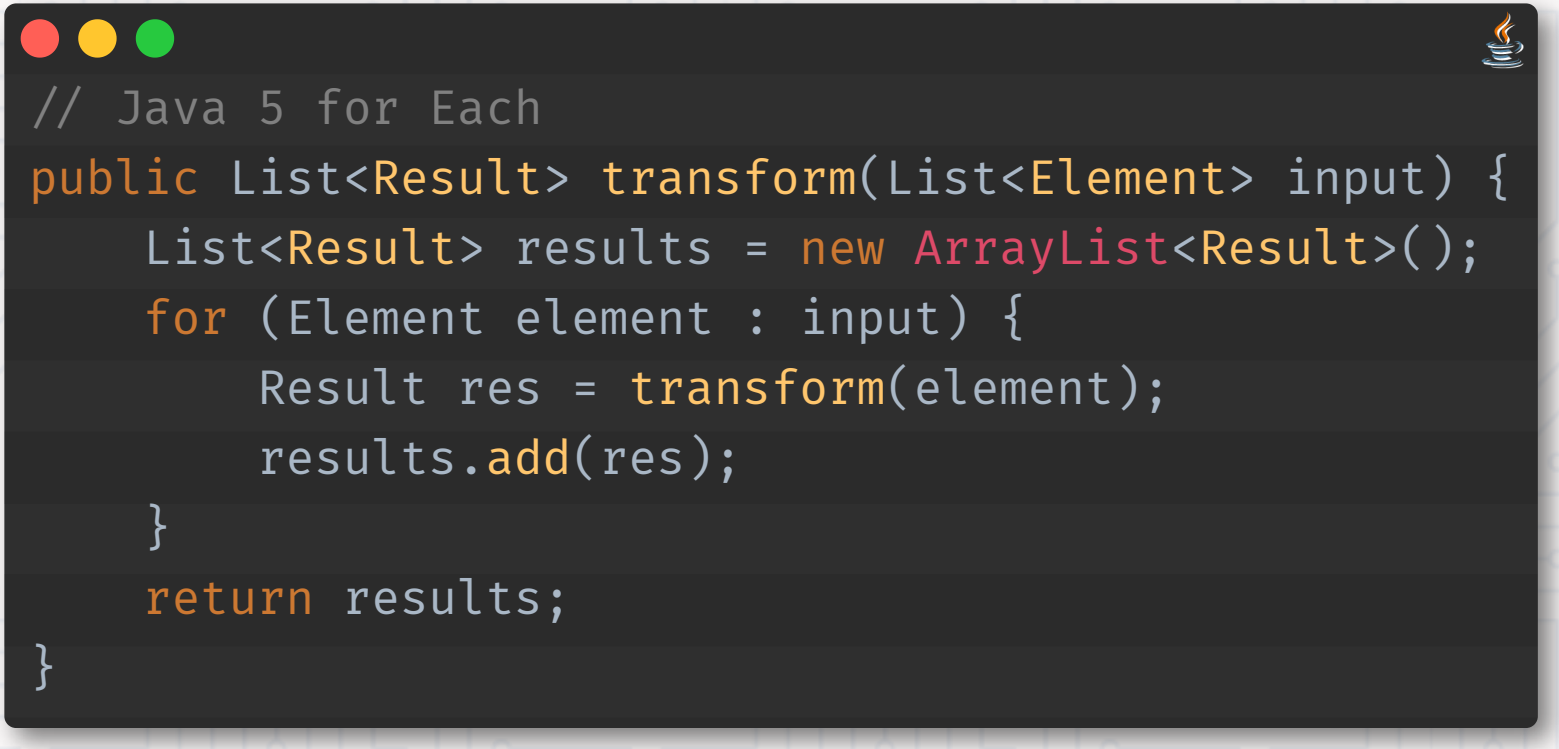
Anatomie d'une boucle

Transformation - Java 1.4



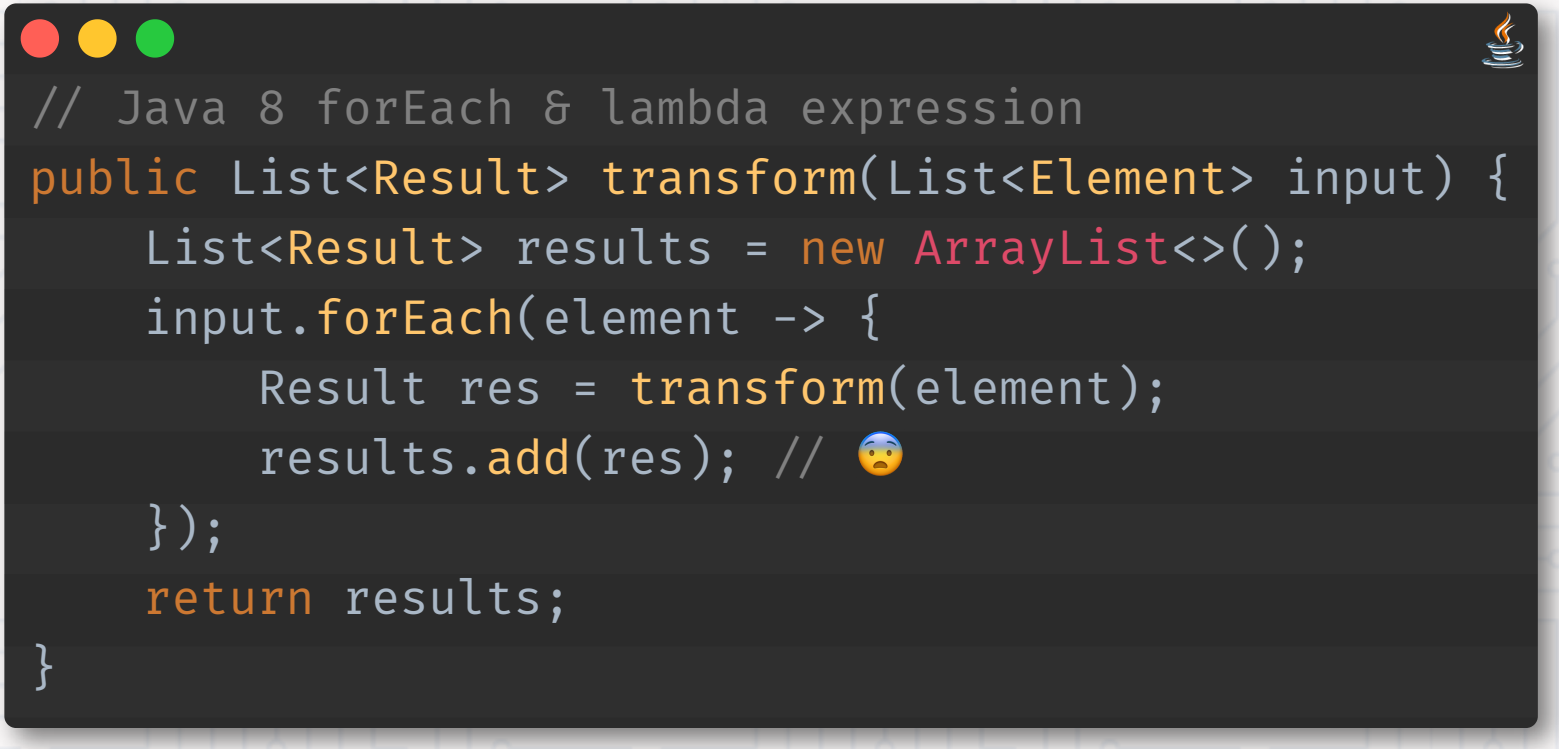
```java
// Good old for style
public List transform(List input) {
    List results = new ArrayList();
    for (int i = 0; i < input.size(); i++) {
        Element element = (Element) input.get(i);
        Result res = transform(element);
        results.add(res);
    }
    return results;
}
```


Transformation - Java 5



```java
// Java 5 for Each
public List<Result> transform(List<Element> input) {
    List<Result> results = new ArrayList<Result>();
    for (Element element : input) {
        Result res = transform(element);
        results.add(res);
    }
    return results;
}
```

Transformation - Java 8



```java
// Java 8 forEach & lambda expression
public List<Result> transform(List<Element> input) {
    List<Result> results = new ArrayList<>();
    input.forEach(element -> {
        Result res = transform(element);
        results.add(res); // 😨
    });
    return results;
}
```

Filtre

```java
public List<Element> filter(List<Element> input) {
    List<Element> results = new ArrayList<>();
    for (Element element : input) {
        if(isSomething(element)) {
            results.add(element);
        }
    }
    return results;
}
```


Accumulation

```java
public Accumulator compute(List<Element> input) {
    Accumulator accumulator = initialValue;
    for (Element element : input) {
        // accumulate :: (Accumulator, Element) → Accumulator
        accumulator = accumulate(accumulator, element);
    }
    return accumulator;
}
```


Imbrication

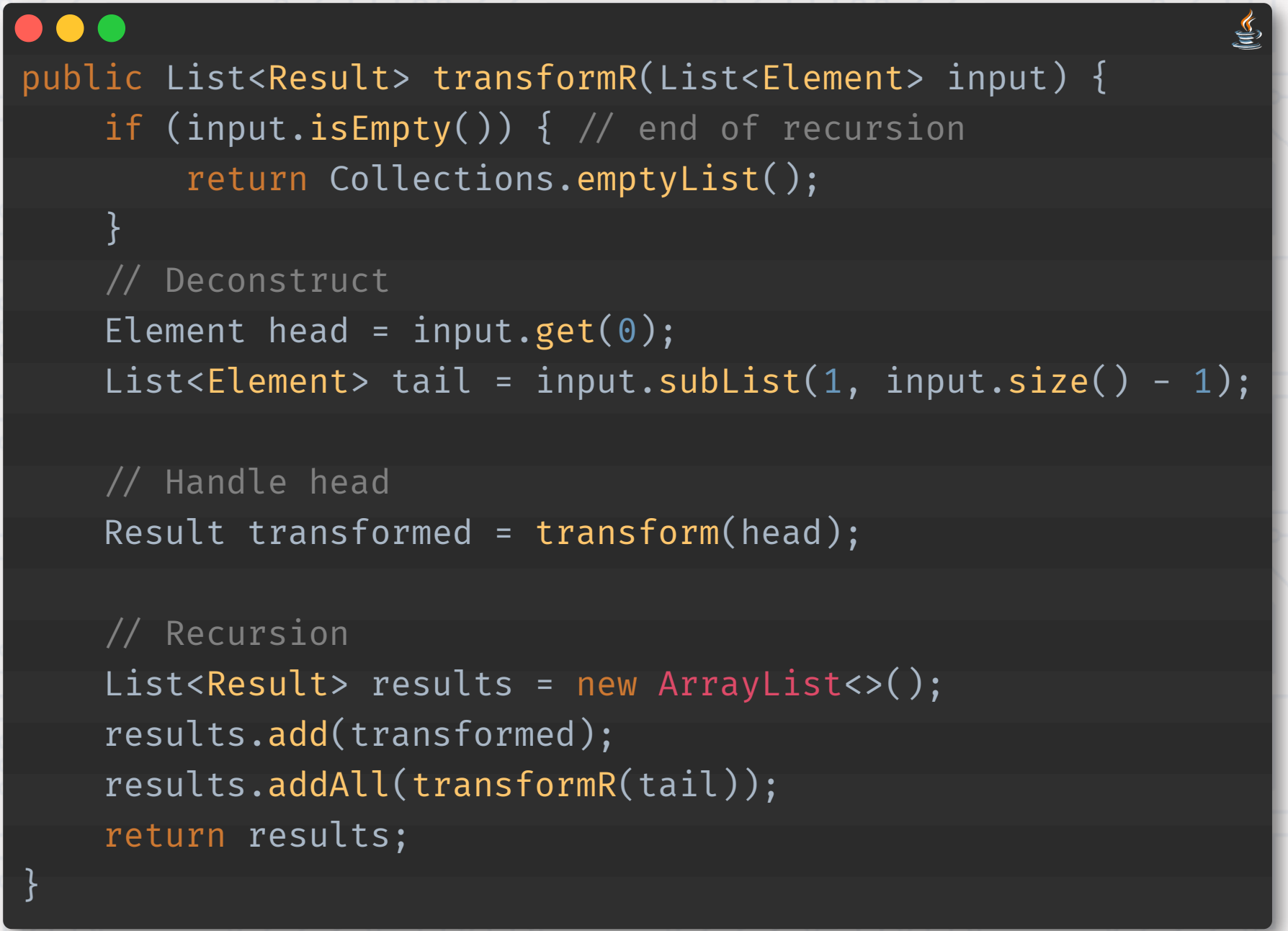
```
for (Element element : input) {
    for (Child child: element.getChildren()) {
        // transform, filter, accumulate, ...
    }
}
```

Et le reste

```
toto: for (Element element : input) {
    tata: for (Child child : element.getChildren()) {
        if(cond1) {
            continue toto;
        } else if (cond2) {
            break tata;
        }
        // ...
    }
}
```

Récursion

Parcours - Java



```java
public List<Result> transformR(List<Element> input) {
    if (input.isEmpty()) { // end of recursion
        return Collections.emptyList();
    }
    // Deconstruct
    Element head = input.get(0);
    List<Element> tail = input.subList(1, input.size() - 1);

    // Handle head
    Result transformed = transform(head);

    // Recursion
    List<Result> results = new ArrayList<>();
    results.add(transformed);
    results.addAll(transformR(tail));
    return results;
}
```

Parcours - Kotlin

```kotlin
fun transformR(input: List<Element>): List<Result> =
    if (input.isEmpty()) listOf()
    else listOf(transform(input.first())) +
            transformR(input.drop(1))
```


Parcours - Scala

```scala
def transformR(input: List[Element]): List[Result] =
  input match {
    case Nil          ⇒ Nil
    case head :: tail ⇒ transform(head) :: transformR(tail)
  }
```


Filtre & Sortie rapide - Java

```java
public Element find(List<Element> input) {
    if (input.isEmpty()) {
        return null;
    }
    Element head = input.get(0);
    if (isSomething(head)) {
        return head;
    }
    List<Element> tail = input.subList(1, input.size());
    return find(tail);
}
```


Récursion non terminale

$$x! = x \times (x-1) \times ... \times 2 \times 1$$
$$1! = 0! = 1$$

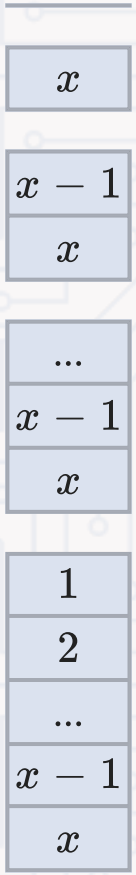
$fact(x)$

$x \times fact(x-1)$

$x \times (x-1) \times fact(x-2)$

$x \times (x-1) \times (x-2) \times ...$

$x \times (x-1) \times (x-2) \times ... \times 2 \times 1$



Récursion terminale

$$fact(x) = fact(x, 1)$$

$$fact(x - 1, x \times 1)$$

$$fact(x - 2, x \times (x - 1))$$

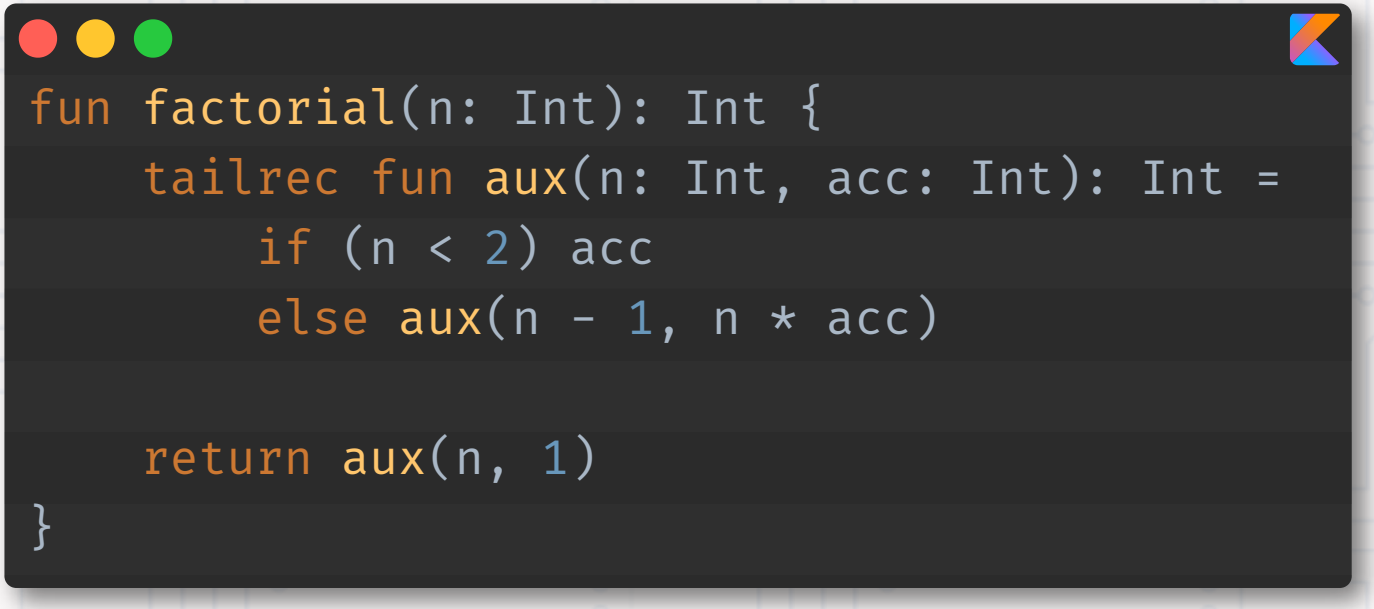
$$fact(..., x \times (x - 1) \times (x - 2) \times ...)$$

$$fact(1, x \times (x - 1) \times (x - 2) \times ... \times 2)$$

⚠️ Nécessite une optimisation par le compilateur

Récursion terminale - Java

Récursion terminale - Kotlin



```kotlin
fun factorial(n: Int): Int {
    tailrec fun aux(n: Int, acc: Int): Int =
        if (n < 2) acc
        else aux(n - 1, n * acc)

    return aux(n, 1)
}
```


Récursion terminale - Scala

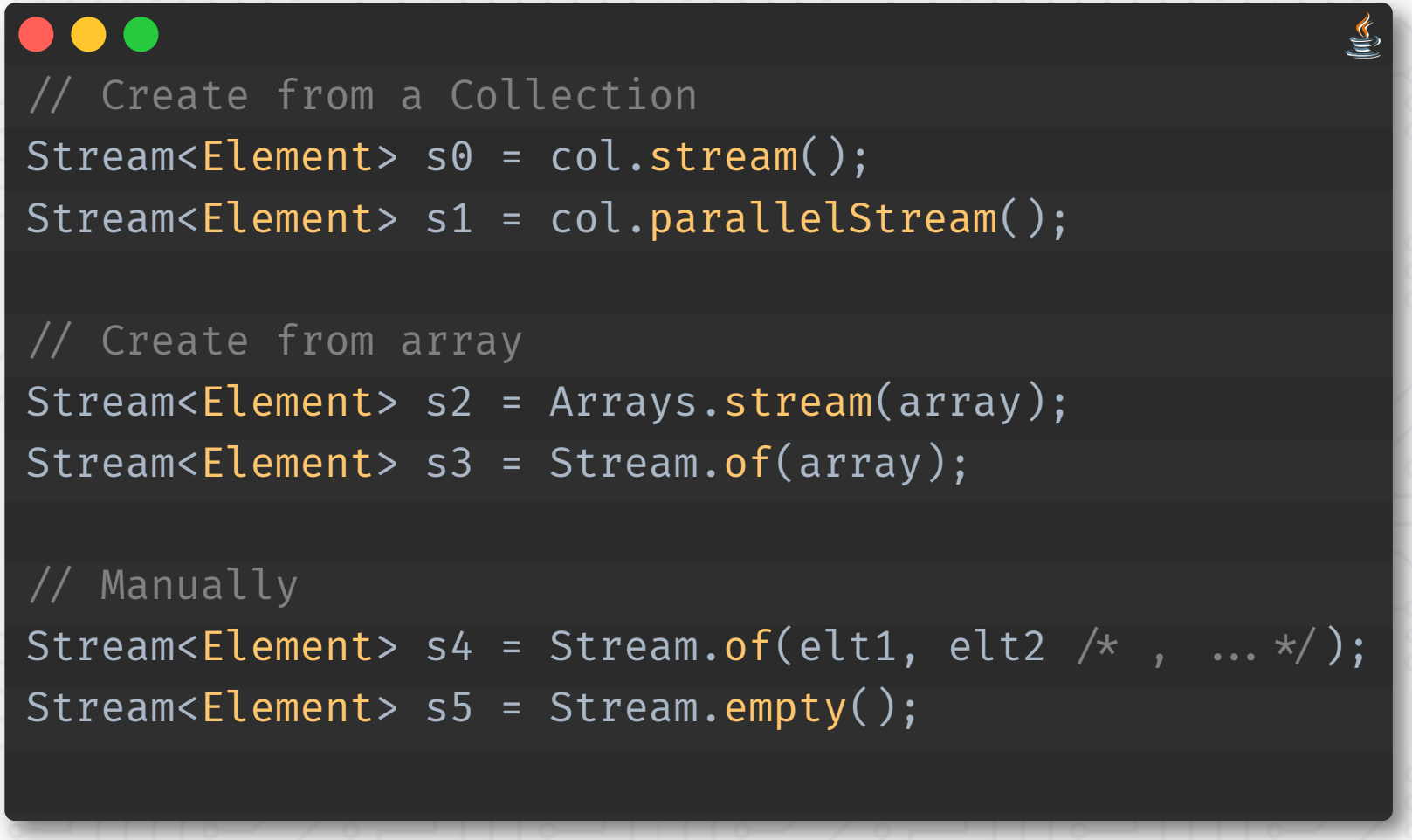
```scala
def factorial(n: Int): Int = {
  @tailrec
  def aux(n: Int, acc: Int): Int =
    if (n < 2) acc
    else aux(n - 1, n * acc)

  aux(n, 1)
}
```


Principe récursion terminale

```
tailRecFunc(scope, state) =
  if (isFinish(scope)) computeResult(state)
  else
    (head, subScope) := scope
    newState := reduce(state, head)
    tailRecFunc(subScope, newState)
```

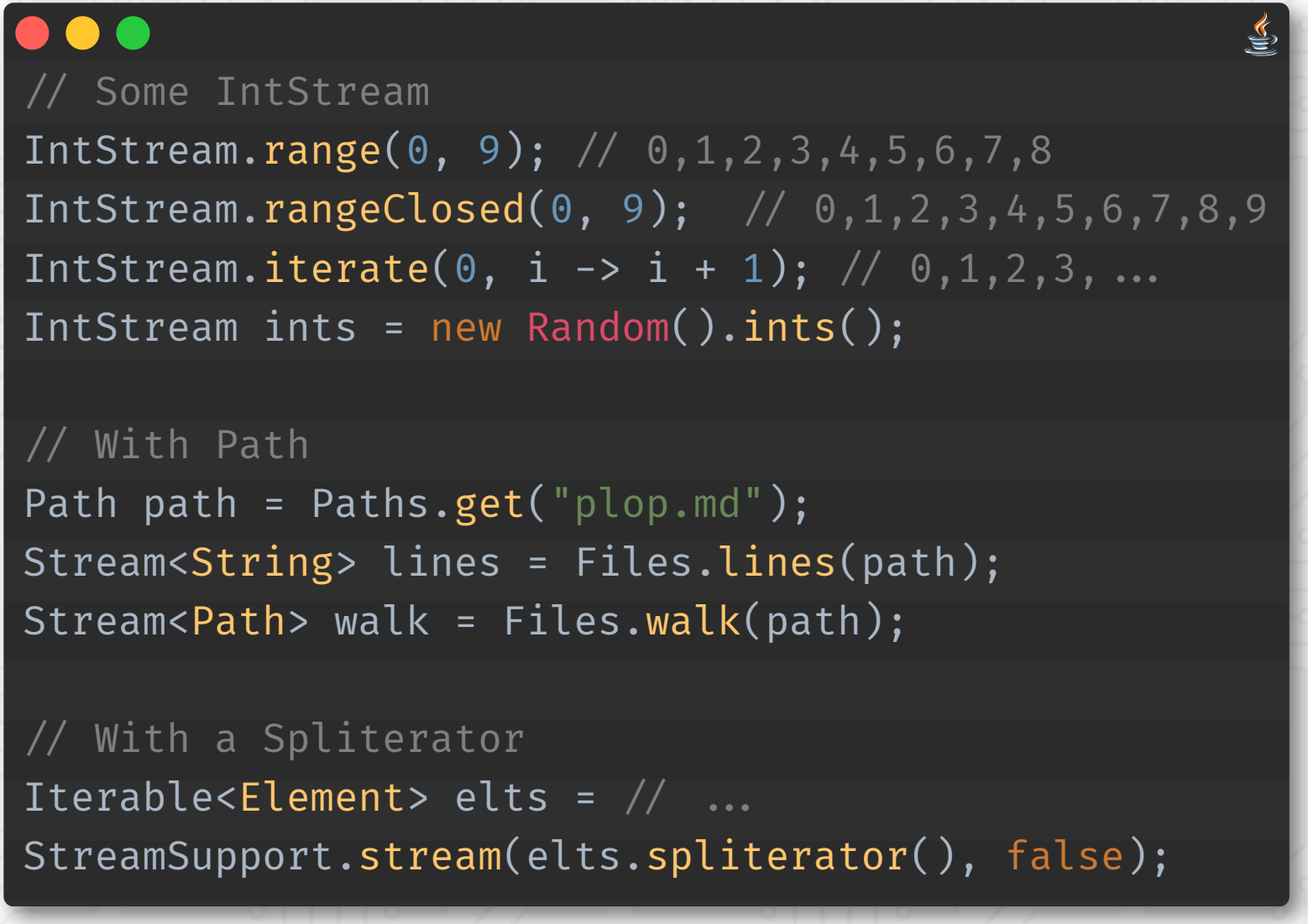

`Stream`

Création 1/2



```java
// Create from a Collection
Stream<Element> s0 = col.stream();
Stream<Element> s1 = col.parallelStream();

// Create from array
Stream<Element> s2 = Arrays.stream(array);
Stream<Element> s3 = Stream.of(array);

// Manually
Stream<Element> s4 = Stream.of(elt1, elt2 /* , ... */);
Stream<Element> s5 = Stream.empty();
```

Création 2/2



```java
// Some IntStream
IntStream.range(0, 9); // 0,1,2,3,4,5,6,7,8
IntStream.rangeClosed(0, 9);  // 0,1,2,3,4,5,6,7,8,9
IntStream.iterate(0, i -> i + 1); // 0,1,2,3, ...
IntStream ints = new Random().ints();

// With Path
Path path = Paths.get("plop.md");
Stream<String> lines = Files.lines(path);
Stream<Path> walk = Files.walk(path);

// With a Spliterator
Iterable<Element> elts = //  ...
StreamSupport.stream(elts.spliterator(), false);
```

Transformation - map

```java
// input: List<Element>
// transform : (Element) → Result
input.stream()
    .map(element -> transform(element))
    // : Stream<Result>
    // ...
    ;
```


Filtre - filter

```java
// input: List<Element>
// isSomething : (Element) → boolean

input.stream()
    .filter(element -> isSomething(element))
    // : Stream<Element>
    // ...
    ;
```


```java
String[] data = "lorem ... amet".split(" ");
Stream<String> stream = Arrays.stream(data)
    .map(s -> {
        System.out.print(s + ",");
            return s.toUpperCase();
    }).filter(s -> {
        System.out.print(s + ",");
        return s.startsWith("A");
    }).peek(s -> System.out.println(s));

System.out.println("Stream created");
```

```
lorem,...,amet,LOREM,...,AMET,AMET
Stream created
```

```
Stream created
```

@ilaborie @toulousejug #flatmap

Opérations paresseuses & terminales

Opérations paresseuses

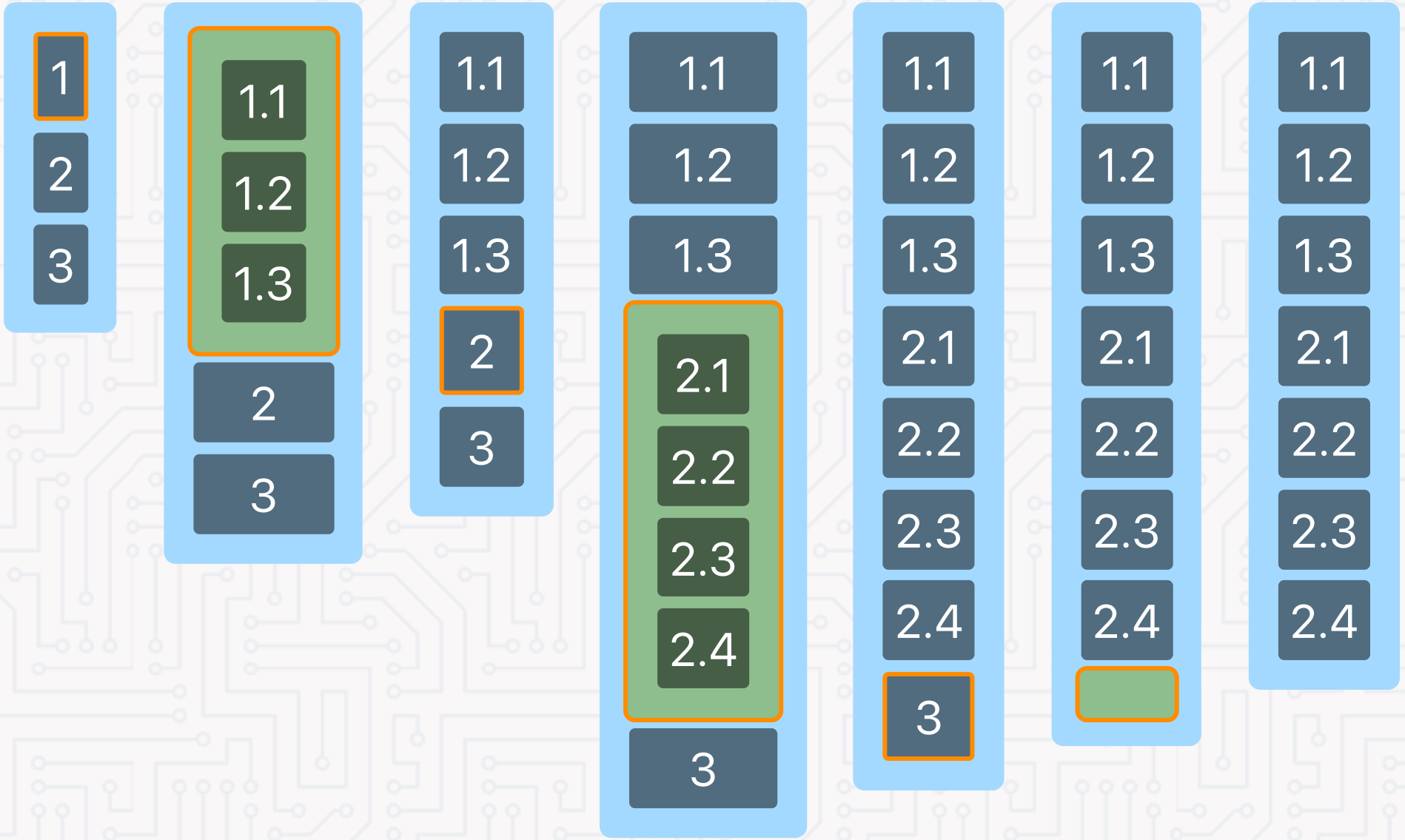
`map`, `filter`, `flatMap`, `peek`, `distinct`, `limit` et `skip`, ...

Opérations terminales

`reduce` et `collect`, `findAny` et `findFirst`, `forEach`, `count`, ...

Imbrication - flatMap 1/2

```java
// input: List<Element>
// Element#getChildren : () → Collection<Child>

input.stream()
     .flatMap(element ->
         element.getChildren().stream())
     // : Stream<Child>
     //  ...
     ;
```


1
2
3
1.1
1.2
1.3
2
3
1.1
1.2
1.3
2
3
1.1
1.2
1.3
2.1
2.2
2.3
2.4
3
1.1
1.2
1.3
2.1
2.2
2.3
2.4
3
1.1
1.2
1.3
2.1
2.2
2.3
2.4
1.1
1.2
1.3
2.1
2.2
2.3
2.4

Accumulation - Reduce 1/2

```java
// input: List<Element>
// accumulate : (Accumulator, Element) → Accumulator
// Accumulator#merge : (Accumulator) → Accumulator

Accumulator result =
    input.stream()
         .reduce(
             new Accumulator(),
             (acc, elt) -> accumulate(acc, elt),
             (acc1, acc2) -> acc1.merge(acc2)
         );
```


Accumulation - Reduce 2/2

✨ **Cas particulier**

Si `Element == Accumulator`, on peut utiliser un `reduce`

Les `count`, `min`, `max`, `sum`, ... sont des réductions particulières

```
// input: List<Element>
// Element#merge : (Element) → Element

Element result =
    input.stream()
         .reduce(
             new Element(),
             (elt1, elt2) -> elt1.merge(elt2)
         );
```


Accumulation - collect & Collectors

Les `Stream#collect` sont justes une généralisation du `reduce`

```
// T: Type du Stream
// A: Type de l'accumulateur
// R: Type du résultat
interface Collector<T,A,R> {
    Supplier<A> supplier()
    BiConsumer<A,T> accumulator();
    BinaryOperator<A> combiner();
    Function<A,R> finisher();
    //  ...
}
```


Collectors classiques

Dans `java.util.stream.Collectors`

`toSet`, `toList` pour construire une collection

`toMap` pour construire un `Map`

`groupBy` pour grouper en une `Map<K,List<V>>`

`joining` pour construire une `String`

`summarizingInt`, `summarizingDouble`, `summarizingLong` pour les statistiques

...

Et l'index ?

Et si j'ai besoin de l'*index* ?

😢 pas faisable facilement et *proprement* en Java

Mais il y a Kotlin et Scala...

Nouveautés Java 9+

Java 9

- `Stream#takeWhile` et `Stream#dropWhile`
- `Stream#iterate` avec un predicat
- `Stream#ofNullable`
- `Optional#stream`
- `Collectors#flatMapping` et `Collectors#filtering`
- `String#chars` et `String#codePoints`

Java 10

- `Collectors#toUnmodifiableXXX` pour les `List`, `Set` et `Map`

Java 11

- `String#lines`

Java 12

- `Collectors#teeing`

Bilan Stream

🚨 **À proscrire**

Les effets de bord ! (on tolère les *logs* dans le `peek`)

Les opérations non associatives dans des `Stream` parallèles

Les streams sur des `Integer`, `Double`, `Long`

⚠️ Sans bonne raison, ne faites pas de `Stream` parallèle

La lisibilité est importante

✨ On peut utiliser intelligemment les aspects paresseux

Bilan Stream - Java

`T reduce(T identity, BinaryOperator<T> accumulator)`
et
`Optional<T> reduce(BinaryOperator<T> accumulator)`

`IntStream`, `DoubleStream`, `LongStream`, avec `mapToObj`, `mapToXXX`, ...

Le *boilerplate*, par exemple `.collect(Collectors.toList())`, `Collectors.groupBy`, ...

Kotlin

😍

API *lazy* avec les `Sequence` ou non directement sur les collections

API collection **immutable** ou mutable

🎭 utilise juste les classes de Java

Scala

API *lazy* avec les `Stream` ou non directement sur les collections

API collection **immutable** ou mutable

Pas de réutilisation de Java

API de ➳ `Stream` <https://www.scala-lang.org/api/2.12.3/scala/collection/immutable/Stream.html> avec la possibilité de construction récursive

> De gros changements arrivent dans la ➳ 2.13 <https://www.scala-lang.org/blog/2018/06/13/scala-213-collections.html>

Scala for

```scala
val monkeyFood = (for {
        fruit ← fruits
        it = emojify(fruit)
        if "🍌" == it || "🥥" == it
    } yield it)
```

Le `for` de Scala est du sucre syntaxique qui produit des `map`, `filter`, `flatMap`

Du coup on peut l'utiliser sur d'autre objects qui ont `map`, `filter`, `flatMap`

Qui est le meilleur ?

Relation d'ordre

Si on veut déterminer le meilleur, ils nous faut une relation d'ordre, laquelle ?

Le plus rapide ?

Le moins couteux en mémoire ?

Le plus maintenable ?

Le plus lisible ?

...

Java & performances

Faire des micro-benchmark en Java, c'est pas évident

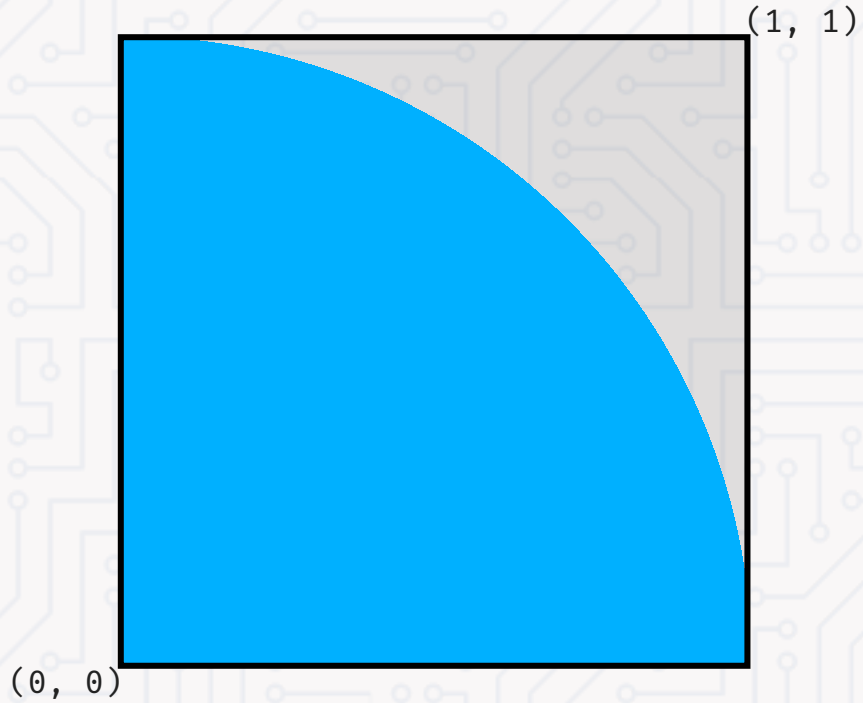
la JVM à besoin de chauffer (JIT)

- JMH <http://openjdk.java.net/projects/code-tools/jmh/>
- Microbenchmarking in Java with JMH (5 articles)

<https://daniel.mitterdorfer.name/articles/2014/jmh-microbenchmarking-intro/>

Rewrite everything in Rust

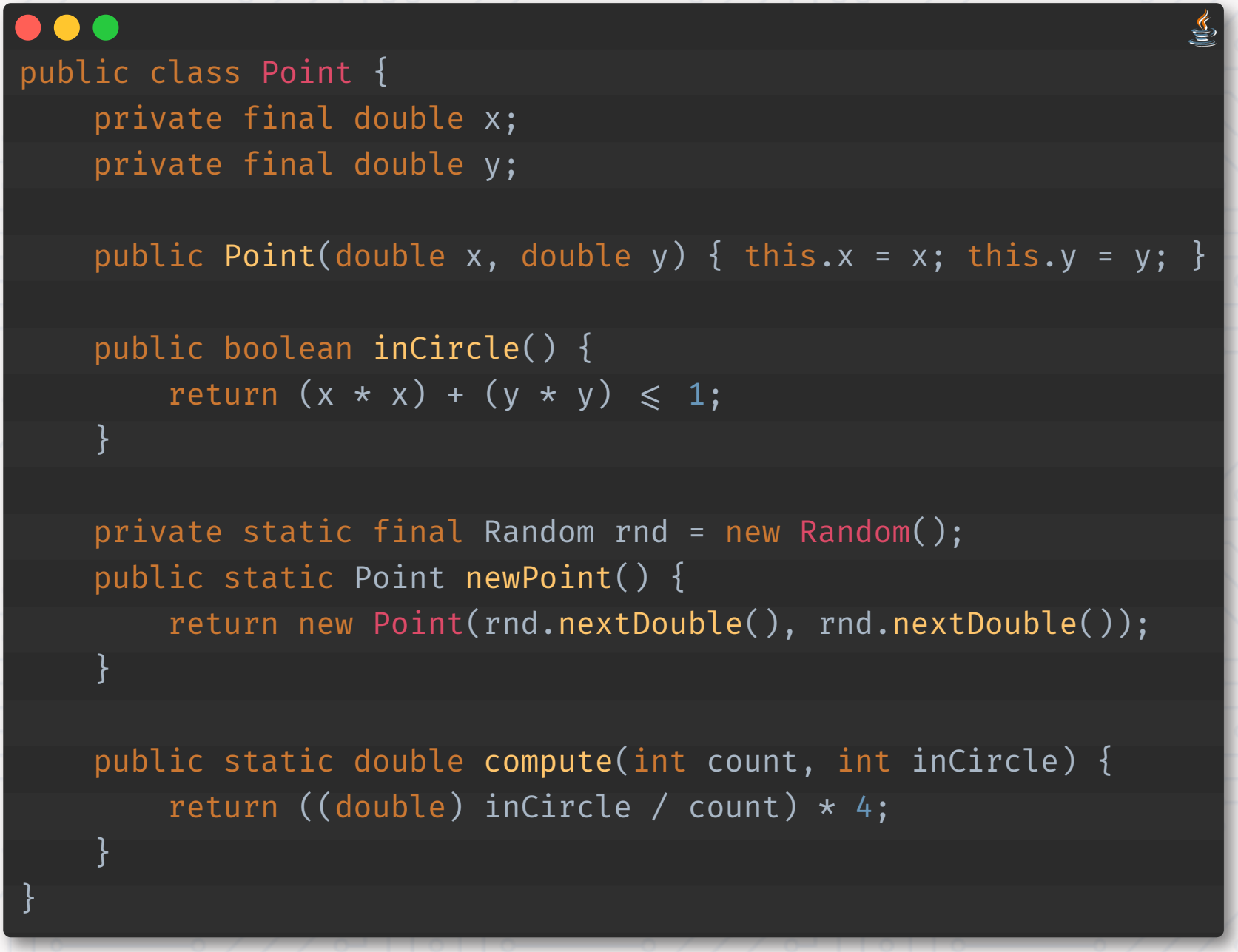
MonteCarlo π



$$\frac{\frac{\pi \cdot r^2}{4}}{r^2} = \frac{\pi}{4} \approx \frac{\text{nb. in}}{\text{nb. total}} \text{ avec } r = 1$$

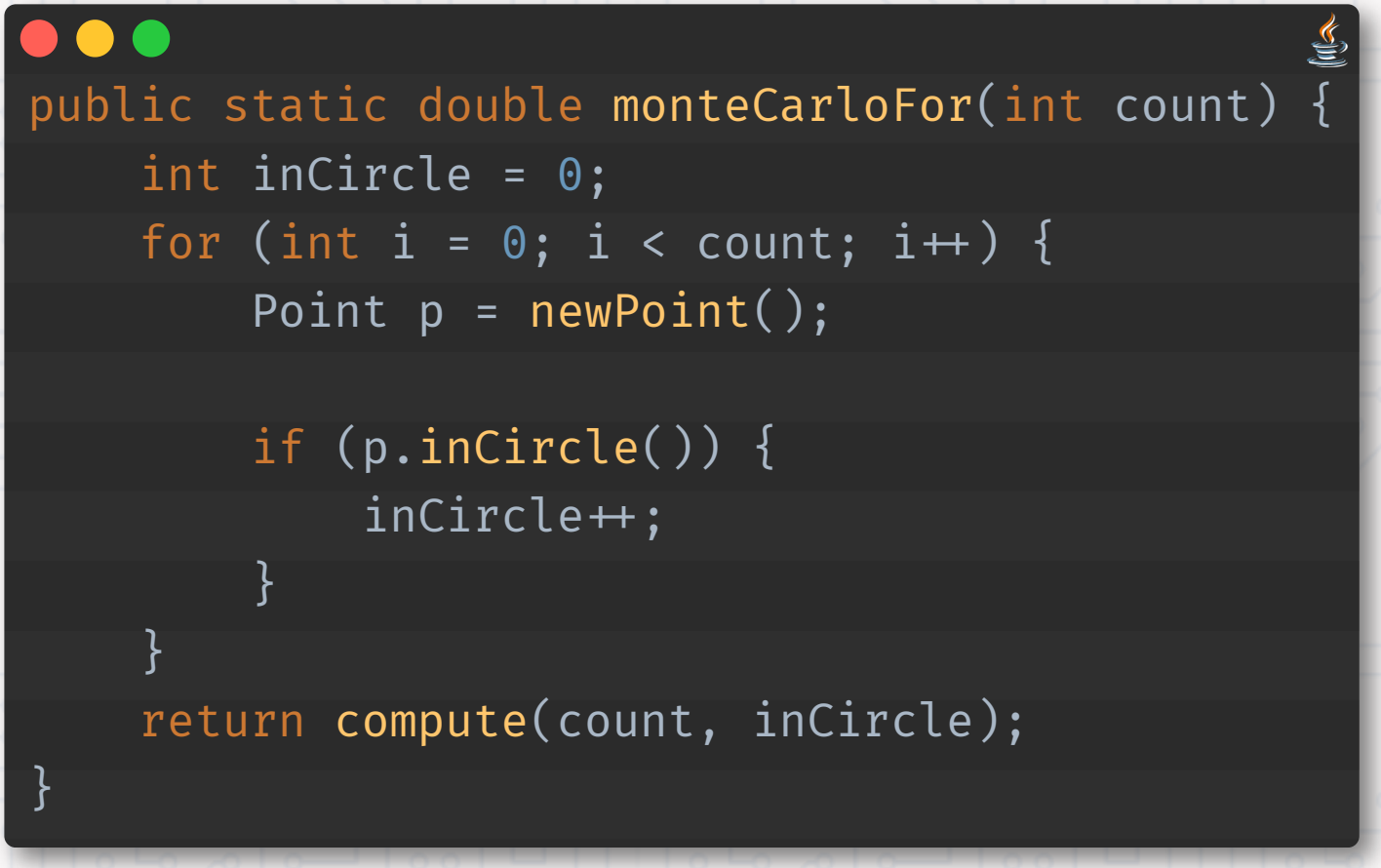
10 points

MonteCarlo - Point



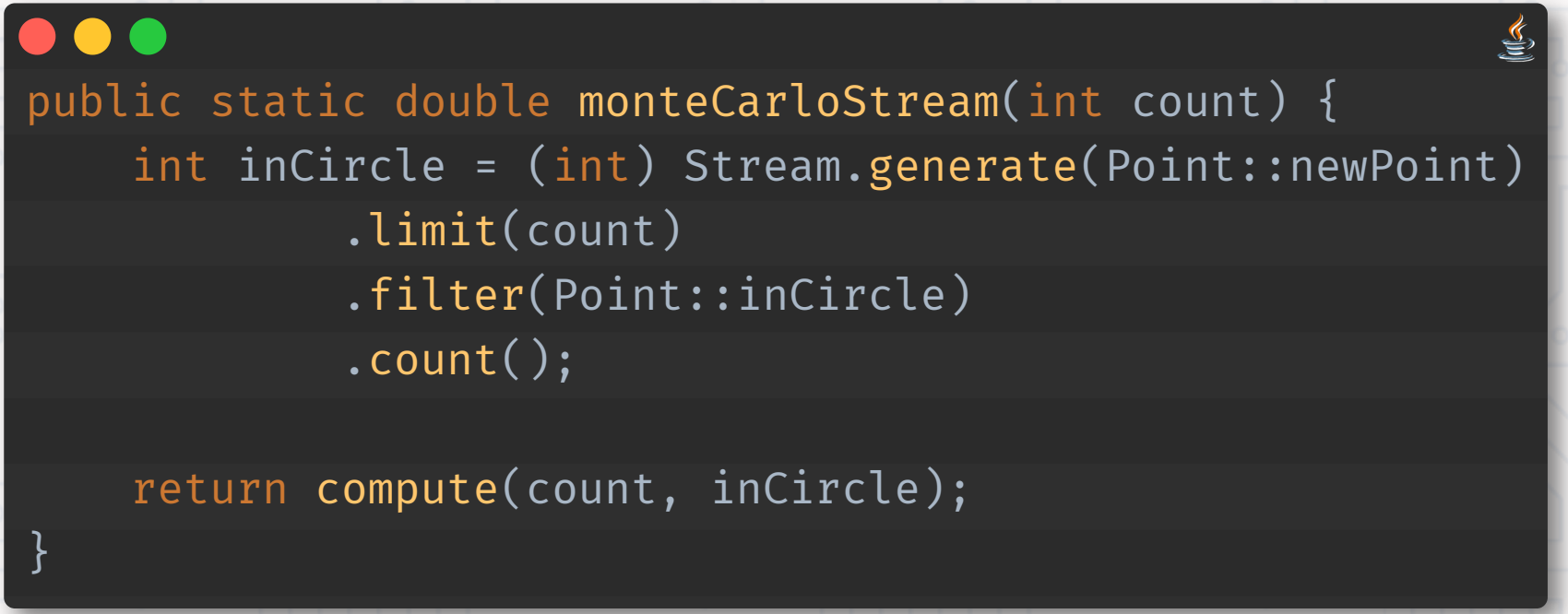
```java
public class Point {
    private final double x;
    private final double y;

    public Point(double x, double y) { this.x = x; this.y = y; }

    public boolean inCircle() {
        return (x * x) + (y * y) ⩽ 1;
    }

    private static final Random rnd = new Random();
    public static Point newPoint() {
        return new Point(rnd.nextDouble(), rnd.nextDouble());
    }

    public static double compute(int count, int inCircle) {
        return ((double) inCircle / count) * 4;
    }
}
```

MonteCarlo - Java for



```java
public static double monteCarloFor(int count) {
    int inCircle = 0;
    for (int i = 0; i < count; i++) {
        Point p = newPoint();

        if (p.inCircle()) {
            inCircle++;
        }
    }
    return compute(count, inCircle);
}
```


MonteCarlo - Java stream

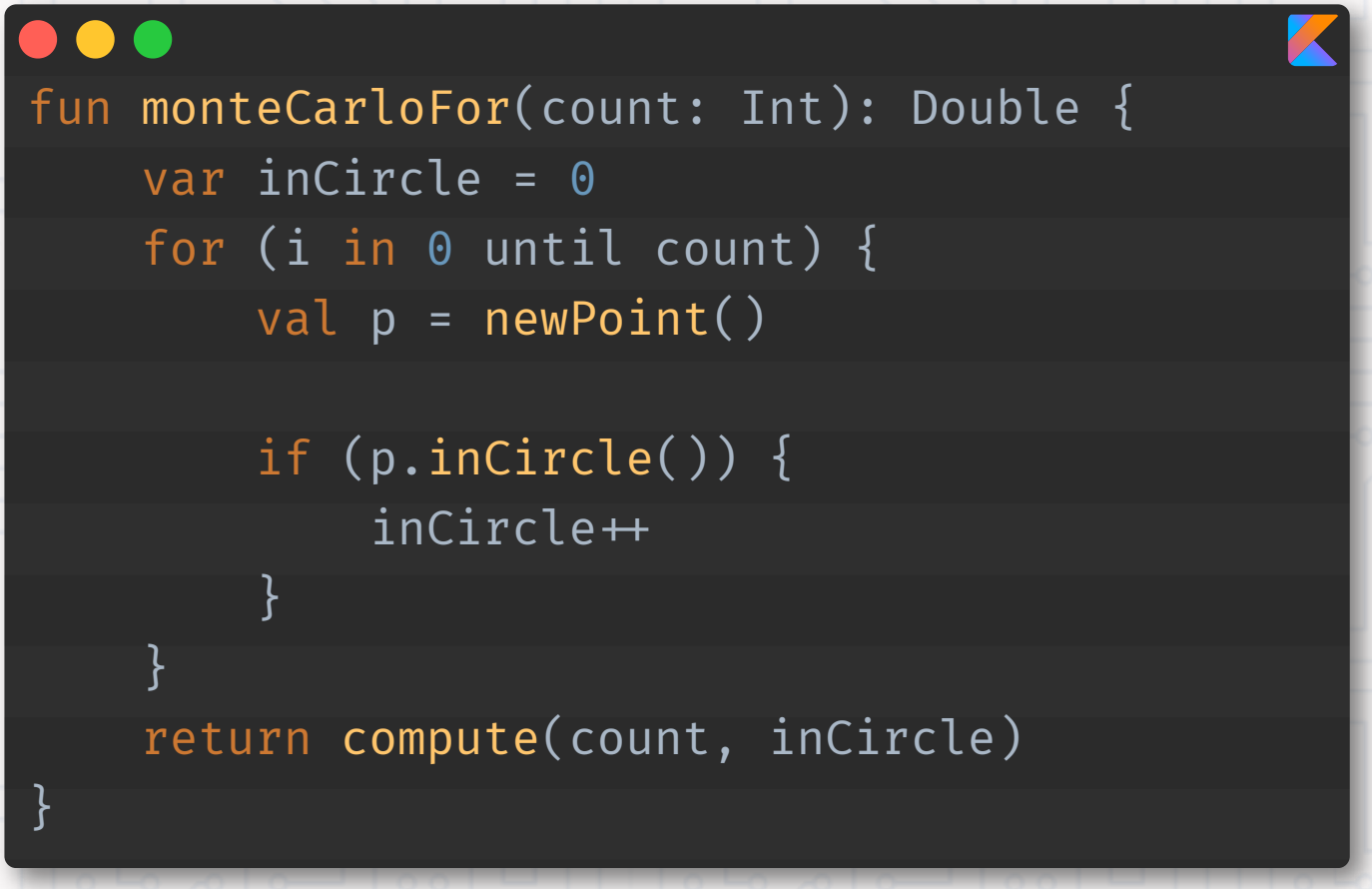


```java
public static double monteCarloStream(int count) {
    int inCircle = (int) Stream.generate(Point::newPoint)
            .limit(count)
            .filter(Point::inCircle)
            .count();

    return compute(count, inCircle);
}
```


MonteCarlo - Java stream parallèle

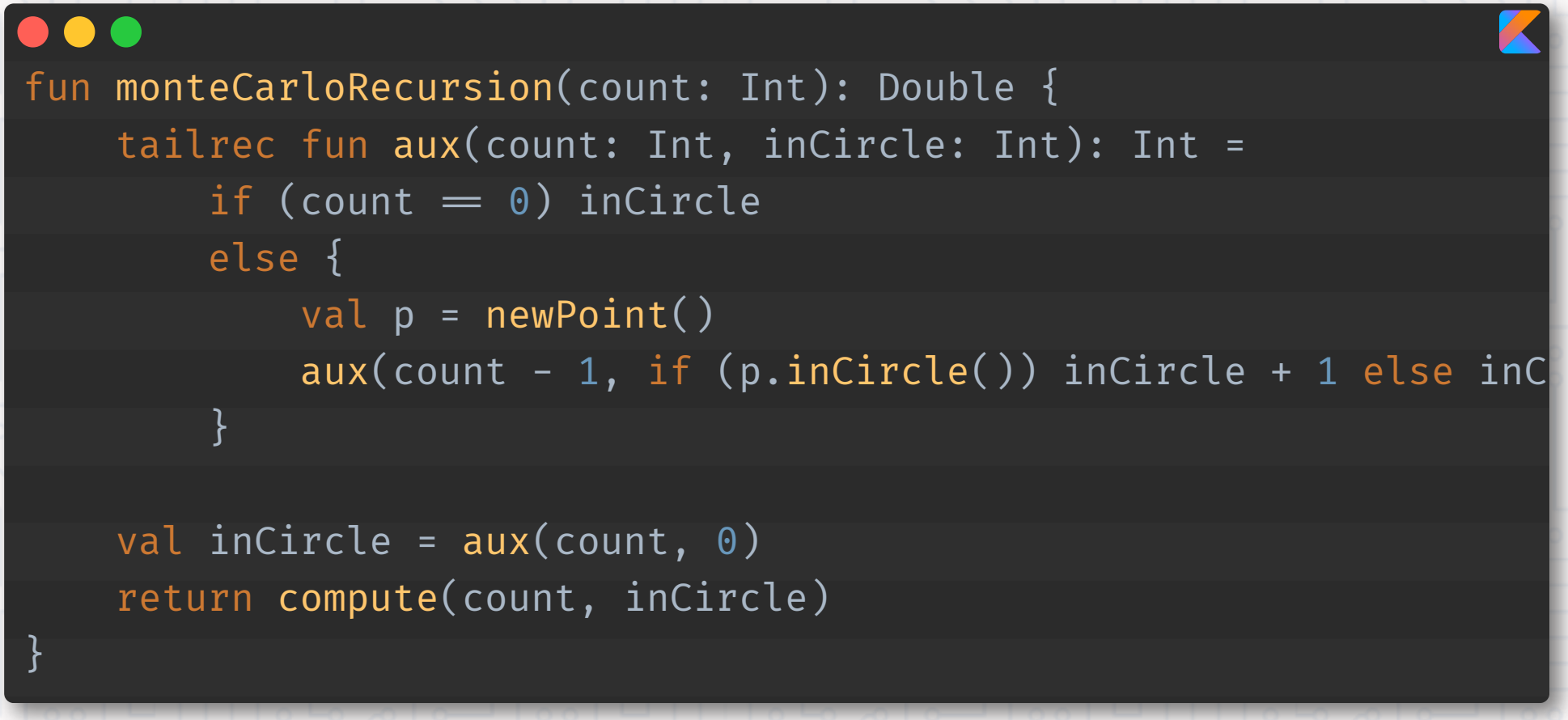
```java
public static double monteCarloStreamParallel(int count) {
    int inCircle = (int) Stream.generate(Point::newPoint)
            .unordered()
            .parallel()
            .limit(count)
            .filter(Point::inCircle)
            .count();

    return compute(count, inCircle);
}
```


MonteCarlo - Kotlin for



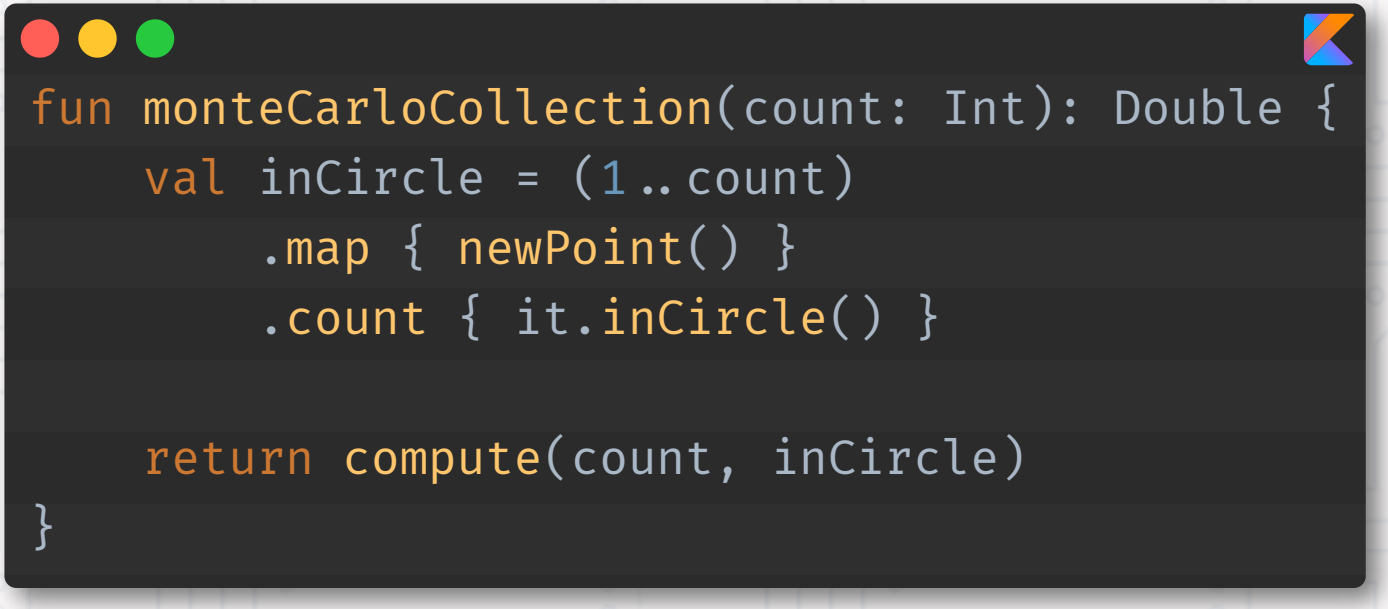
```kotlin
fun monteCarloFor(count: Int): Double {
    var inCircle = 0
    for (i in 0 until count) {
        val p = newPoint()

        if (p.inCircle()) {
            inCircle++
        }
    }
    return compute(count, inCircle)
}
```

MonteCarlo - Kotlin tailrec



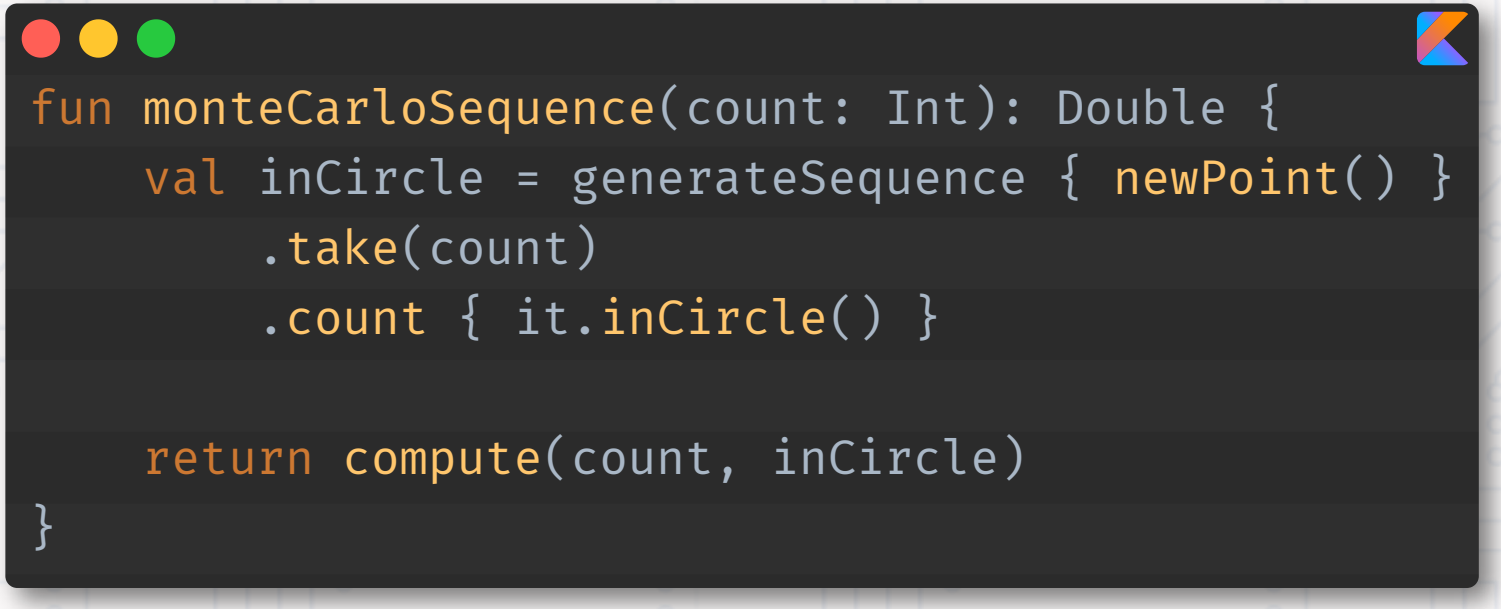
```kotlin
fun monteCarloRecursion(count: Int): Double {
    tailrec fun aux(count: Int, inCircle: Int): Int =
        if (count == 0) inCircle
        else {
            val p = newPoint()
            aux(count - 1, if (p.inCircle()) inCircle + 1 else inC
        }

    val inCircle = aux(count, 0)
    return compute(count, inCircle)
}
```

MonteCarlo - Kotlin collection



```kotlin
fun monteCarloCollection(count: Int): Double {
    val inCircle = (1..count)
        .map { newPoint() }
        .count { it.inCircle() }

    return compute(count, inCircle)
}
```


MonteCarlo - Kotlin séquence



```kotlin
fun monteCarloSequence(count: Int): Double {
    val inCircle = generateSequence { newPoint() }
        .take(count)
        .count { it.inCircle() }

    return compute(count, inCircle)
}
```

MonteCarlo - Kotlin séquence parallèle

```kotlin
fun monteCarloSequenceParallel(count: Int): Double {
    val inCircle = sequence {
        yieldAll(generateSequence { newPoint() })
    }
        .take(count)
        .count { it.inCircle() }

    return compute(count, inCircle)
}
```


MonteCarlo - Scala for

```scala
def monteCarloFor(count: Int): Double = {
    var inCircle = 0
    for (_ ← 1 to count) {
      val p = newPoint()

      if (p.inCircle()) {
        inCircle += 1
      }
    }
    compute(count, inCircle)
  }
```


MonteCarlo - Scala tailrec

```scala
def monteCarloRecursion(count: Int): Double = {
    @tailrec
    def aux(count: Int, inCircle: Int): Int =
      if (count == 0) inCircle
      else {
        val p = newPoint()
        aux(count - 1, inCircle + (if (p.inCircle()) 1 else 0))
      }

    val inCircle = aux(count, 0)
    compute(count, inCircle)
  }
```


MonteCarlo - Scala collection

```scala
def monteCarloCollection(count: Int): Double = {
    val inCircle = (1 to count)
      .map(_ ⇒ newPoint())
      .count(_.inCircle())

    compute(count, inCircle)
  }
```


MonteCarlo - Scala stream

```scala
def monteCarloStream(count: Int): Double = {
    val inCircle = Stream.fill(count) {
      newPoint()
    }
      .count(_.inCircle())

    compute(count, inCircle)
  }
```


MonteCarlo - Scala stream parallèle

```scala
def monteCarloStreamParallel(count: Int): Double = {
    val inCircle = Stream.fill(count) {
      newPoint()
    }
      .par
      .count(_.inCircle())

    compute(count, inCircle)
  }
```

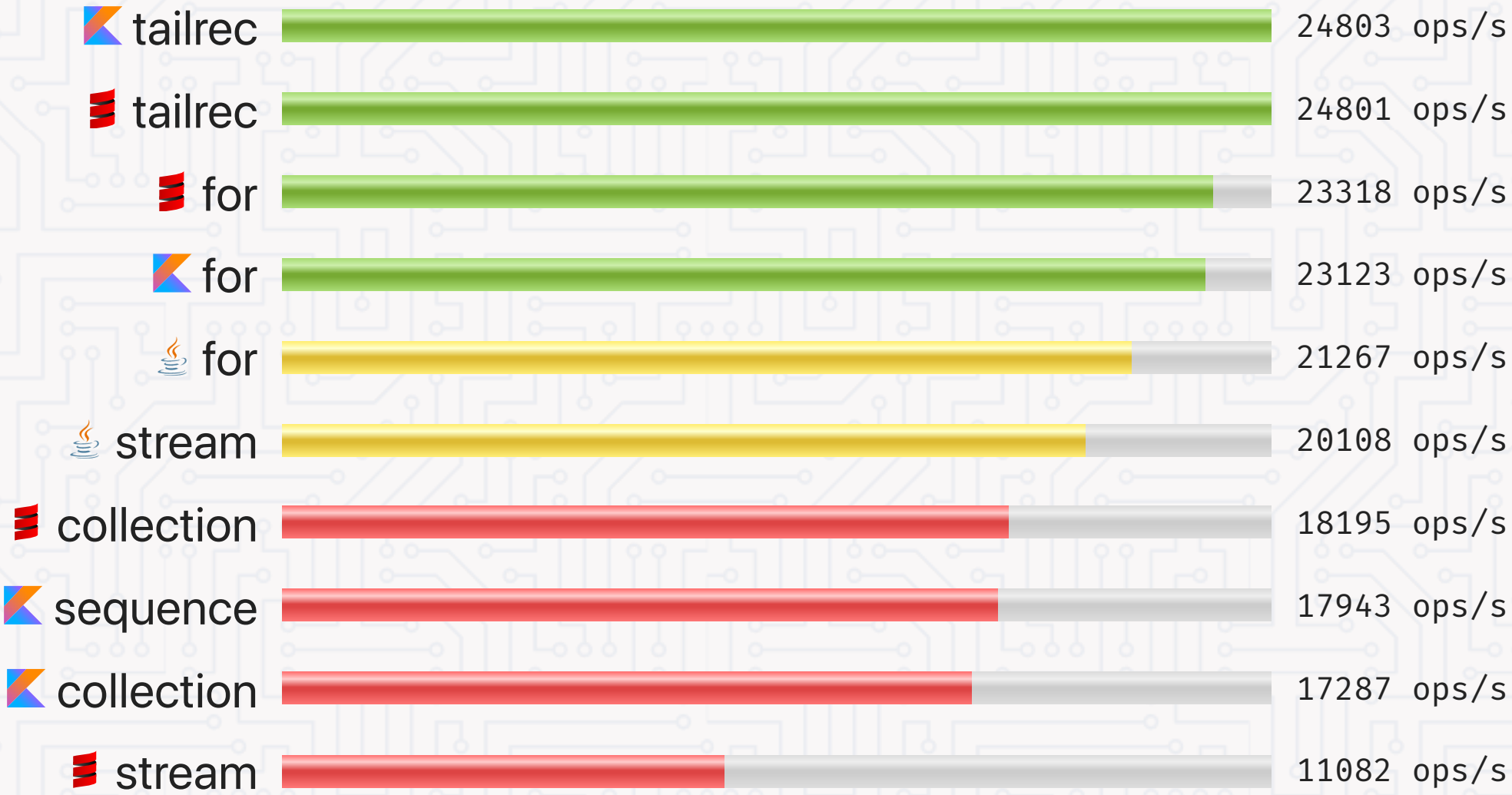

Disclaimer

> *"REMEMBER: The numbers below are just data. To gain reusable insights, you need to follow up on why the numbers are the way they are. Use* ***profilers*** *(see* `-prof`, `-lprof`*), design factorial experiments, perform baseline and negative tests that provide experimental control, make sure the benchmarking environment is safe on JVM/OS/HW level,* ***ask for reviews*** *from the domain experts.*
> ***Do not assume the numbers tell you what you want them to tell.***

=> Venez lire, tester, critiquer, proposer des PR sur le ➳ dépôt Github

<https://github.com/ilaborie/refactorLoops>

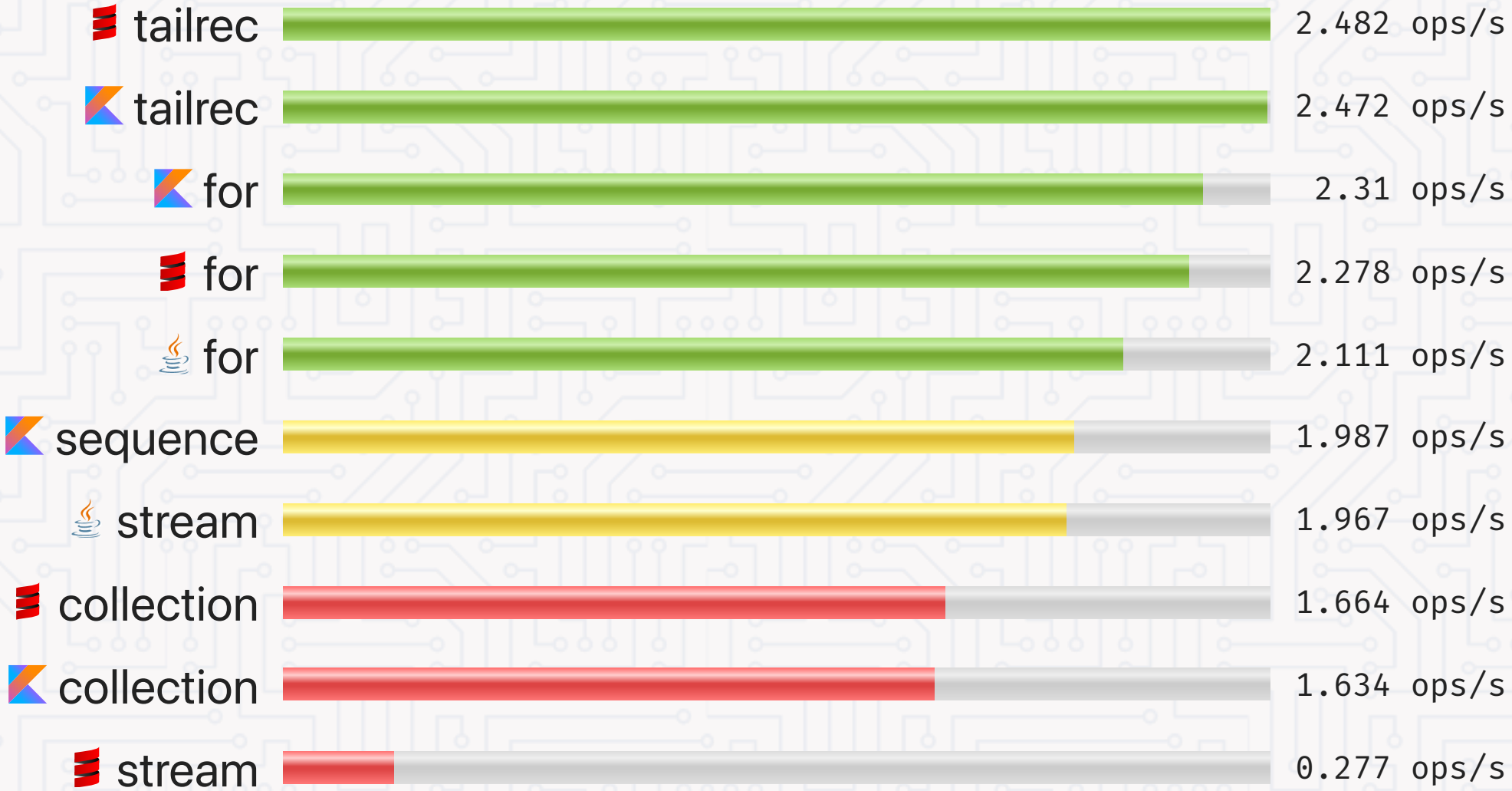
MonteCarlo - performance 1000 points



1_000 points sur OpenJDK (HotSpot) 8.0.202

$$\text{tailrec} \approx 40.3\mu s > \text{for} \approx 47.0\mu s > \text{stream} \approx 49.7\mu s > \text{collection} \approx 55.0\mu s$$

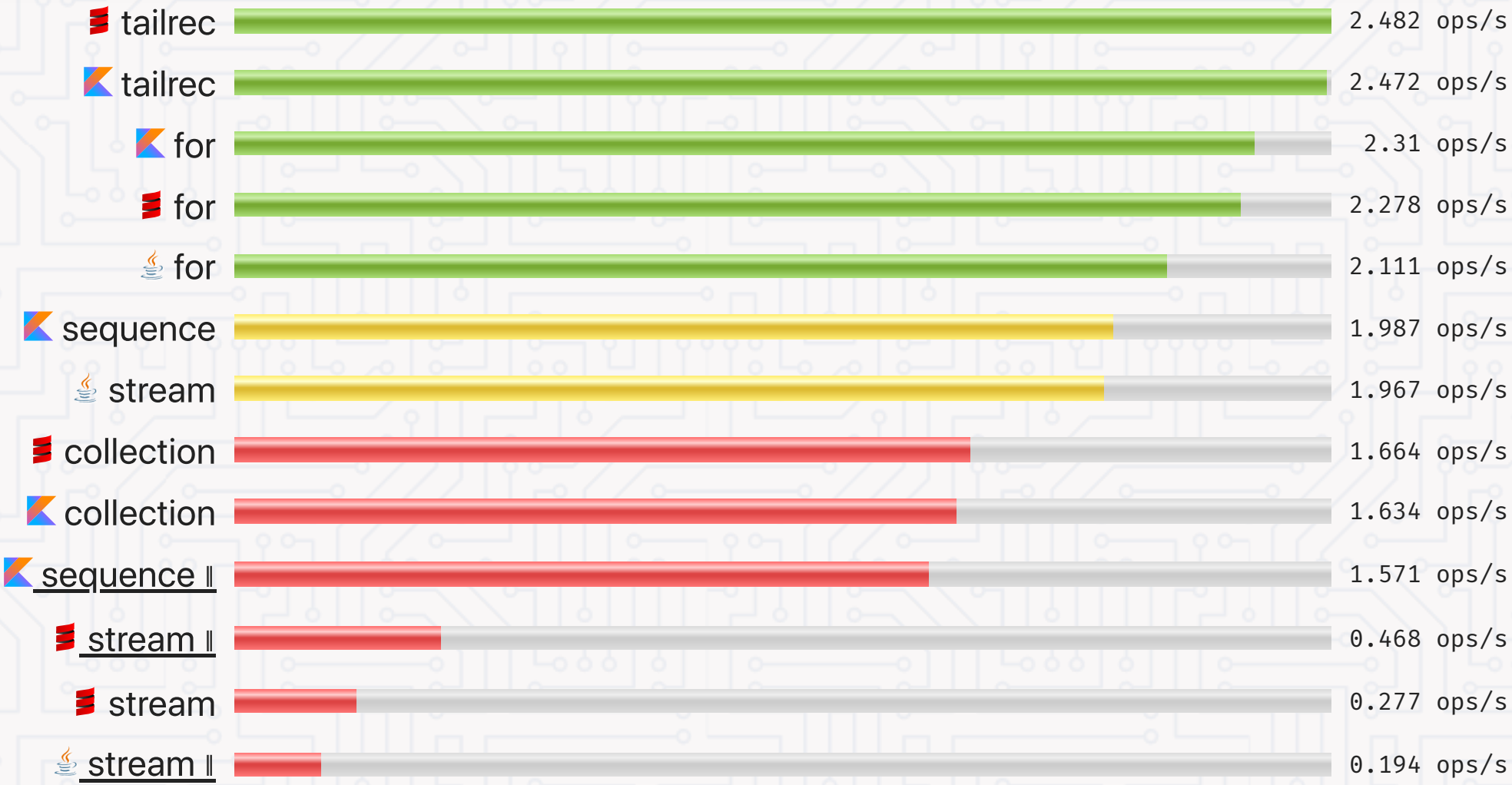
MonteCarlo - performance 10M points



10_000_000 points sur OpenJDK (HotSpot) 8.0.202

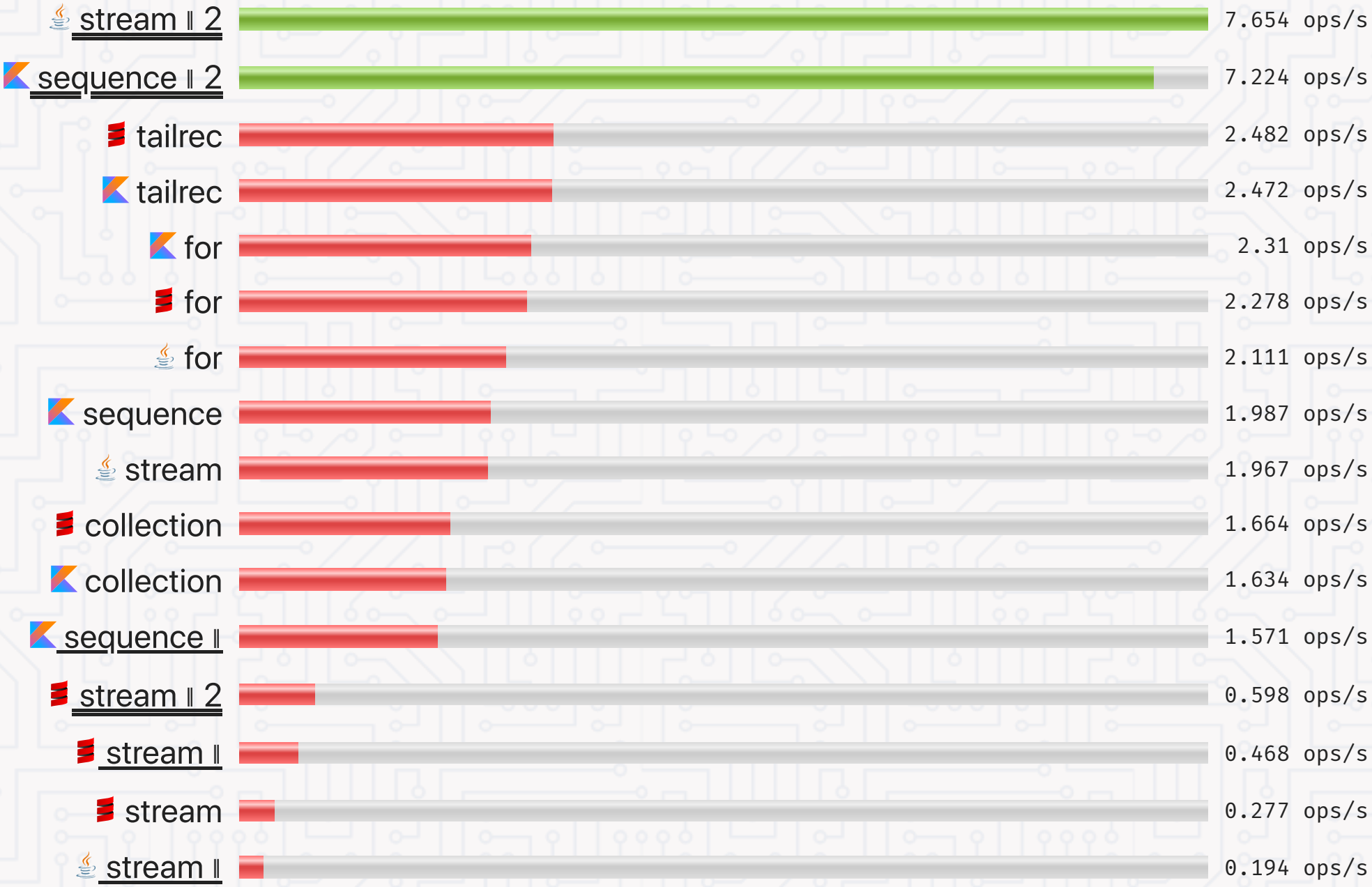
$$\text{tailrec} \approx 403ms > \text{for} \approx 474ms > \text{stream} \approx 508ms > \text{collection} \approx 601ms$$

MonteCarlo - performance parallèle



10_000_000 points sur OpenJDK (HotSpot) 8.0.202

😱 le code parallèle



10_000_000 points sur OpenJDK (HotSpot) 8.0.202

SplittableRandom

Depuis Java 8 ➳ `SplittableRandom`

<https://docs.oracle.com/javase/8/docs/api/java/util/SplittableRandom.html>

Separation of Concerns

Imperative vs. Functional Separation of Concerns

```
List<String> errors = new ArrayList<>();
int errorCount = 0;
File file = new File(fileName);
String line = file.readLine();
while (errorCount < 40 && line != null) {
    if (line.startsWith("ERROR")) {
        errors.add(line);
        errorCount++;
    }
    line = file.readLine();
}
```

```
List<String> errors =
    Files.lines(Paths.get(fileName))
        .filter(l -> l.startsWith("ERROR")
        .limit(40)
        .collect(toList());
```

- **@mariofusco** <https://twitter.com/mariofusco/status/571999216039542784>
- Lazy Java par Mario Fusco <https://www.youtube.com/watch?v=84MfG4tp30s>

Prédisposition aux 

```java
// Good old for style
public List transform(List input) {
    List results = new ArrayList();
    for (int i = 0; i < input.size(); i++) {
        Element element = (Element) input.get(i);
        Result res = transform(element);
        results.add(res);
    }
    return results;
}
```


Prédisposition aux 🐛 dangereux

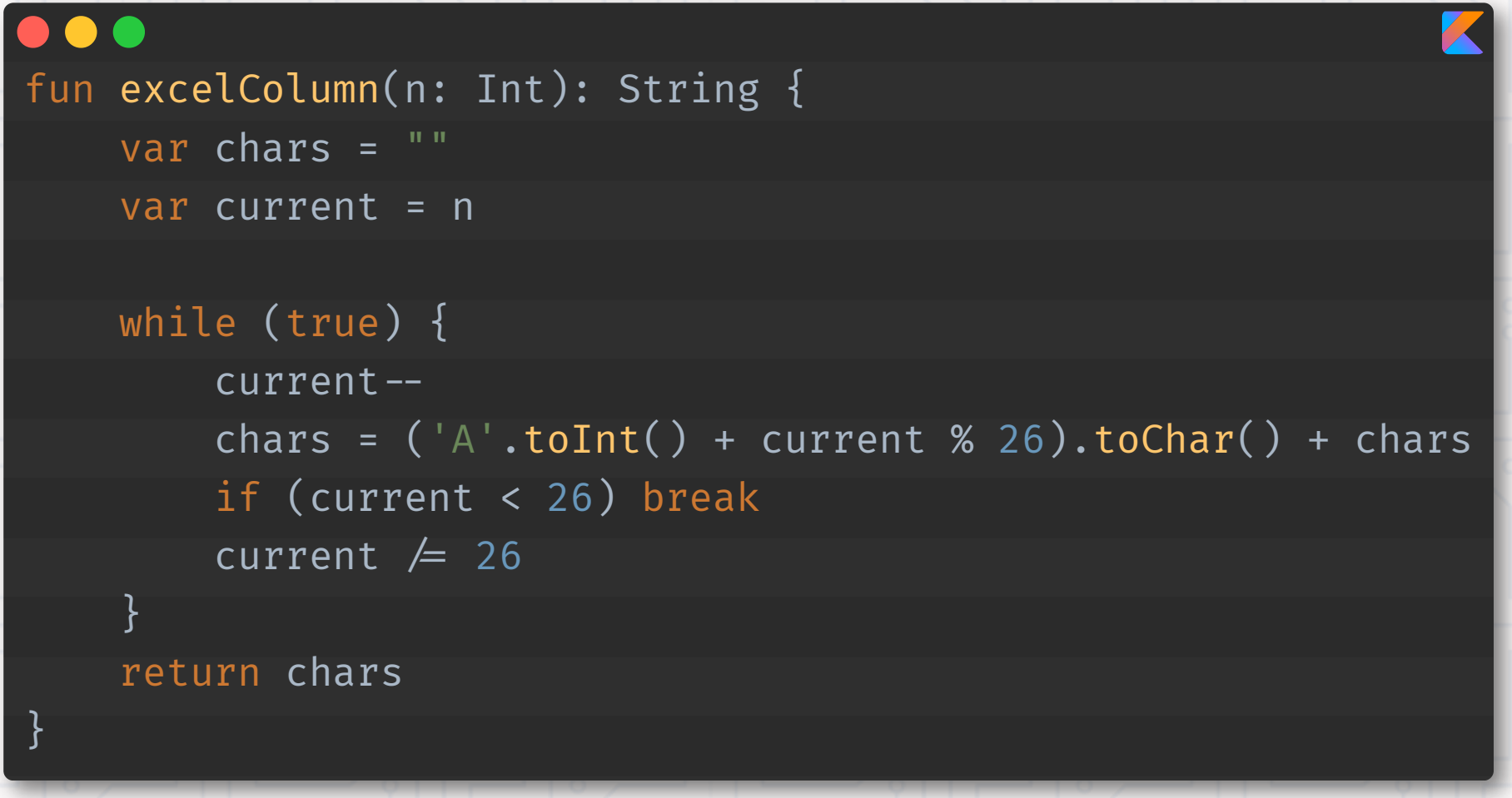
```java
// Java 8 forEach & lambda expression
public List<Result> transform(List<Element> input) {
    List<Result> results = new ArrayList<>();
    input.forEach(element -> {
        Result res = transform(element);
        results.add(res); // 😨
    });
    return results;
}
```


Pas tous du même avis

➳ 3 Reasons why You Shouldn’t Replace Your for-loops by Stream forEach <https://www.javacodegeeks.com/2015/12/3-reasons-shouldnt-replace-loops-stream-foreach.html>

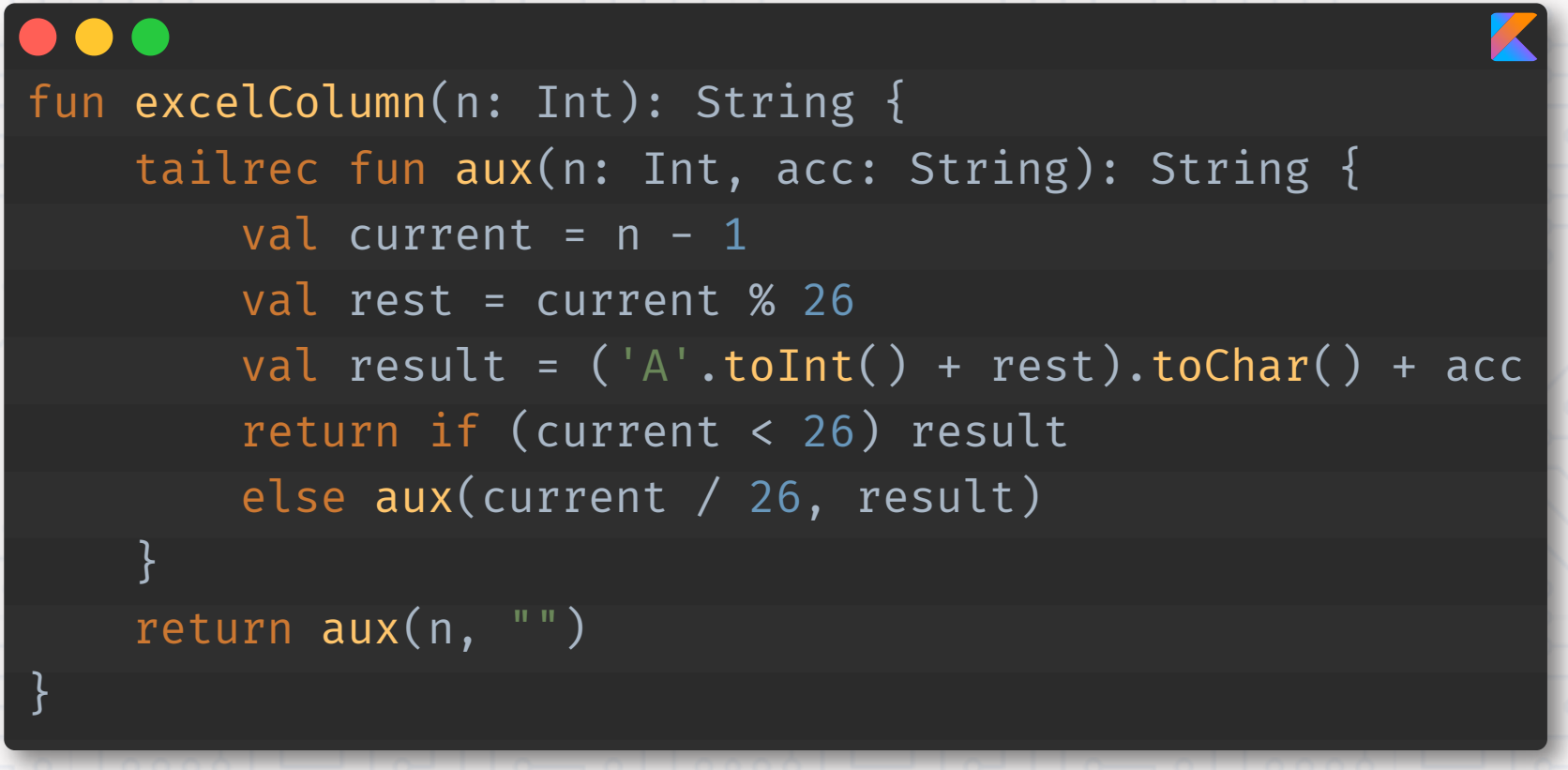
Exemple colonnes d'Excel - for

A, B, ..., Z, AA, AB, ..., ZZ, AAA, ...



```kotlin
fun excelColumn(n: Int): String {
    var chars = ""
    var current = n

    while (true) {
        current--
        chars = ('A'.toInt() + current % 26).toChar() + chars
        if (current < 26) break
        current /= 26
    }
    return chars
}
```

Exemple colonnes d'Excel - récursif



```kotlin
fun excelColumn(n: Int): String {
    tailrec fun aux(n: Int, acc: String): String {
        val current = n - 1
        val rest = current % 26
        val result = ('A'.toInt() + rest).toChar() + acc
        return if (current < 26) result
        else aux(current / 26, result)
    }
    return aux(n, "")
}
```

Exemple colonnes d'Excel - séquence

```kotlin
fun excelColumn(n: Int): String =
    generateSequence<Pair<Int?, String>>(n to "") { (n, acc) →
        if (n == null) null
        else {
            val current = n - 1
            val result = ('A'.toInt() + current % 26).toChar() + a

            if (current < 26) null to result
            else (current / 26) to result
        }
    }.last().second
```

Conclusion

Bilan

`goto` firstQuote

> *Les frameworks et bibliothèques naissent et meurent, les bases et les styles de programmation restent.*

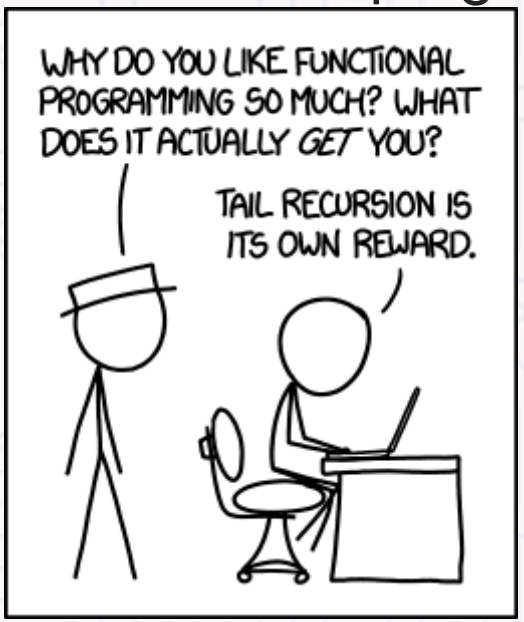
> *Il suffit de choisir le langage, les frameworks, et les bibliothèques qui correspondent aux styles.*
> *Choisissiez un style qui correspond à vos contraintes et vos goûts.*

➽ Si vous avez du mal à choisir <http://www.flatmapthatshit.com/>

FP

Lambda et fonctions d'ordre supérieur
Pas d'effet de bord
Immutablilté

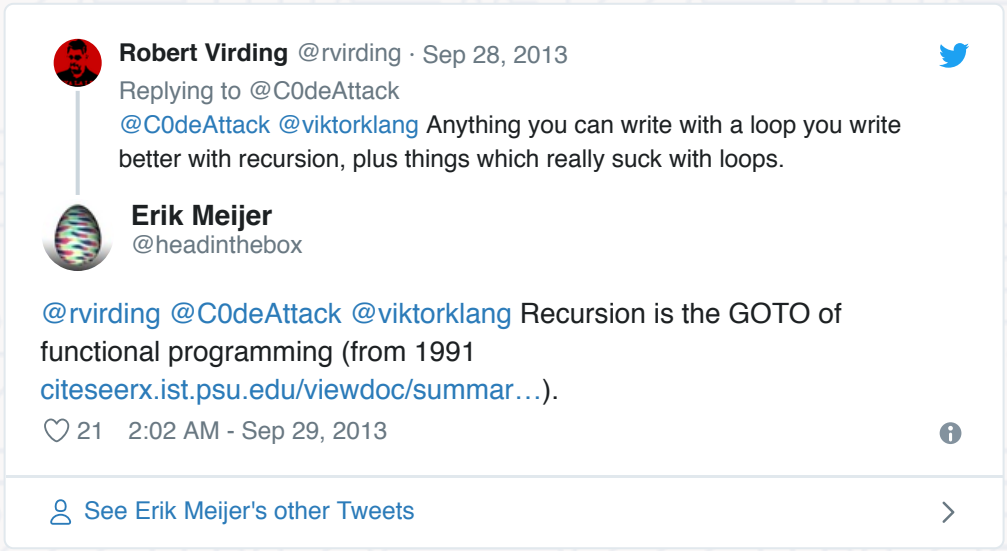
⇒ Ceci est une présentation sur la programmation fonctionnelle



➳ https://xkcd.com/1270/ <https://xkcd.com/1270/>

➽ Functional Programming with Bananas, Lenses, Envelopes and Barbed Wire <http://eprints.eemcs.utwente.nl/7281/01/db-utwente-40501F46.pdf> - Erik Meijer and J. Hughes and M.M. Fokkinga and Ross Paterson" - 1991

> *"We develop a calculus for lazy functional programming based on recursion operators associated with data type definitions. For these operators we derive various algebraic laws that are useful in deriving and manipulating programs. We shall show that all example functions in Bird and Wadler's "Introduction to Functional Programming" can be expressed using these operators.*



Crafters

❓ Quand vous codez, posez-vous des questions !

🔪 Aiguisez votre esprit critique !

🗣️ Partagez vos questionnements, vos solutions, vos idées farfelues !

🍕 ou ❓