scalafmt: opinionated code formatter for Scala

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Today's agenda

1. Introduction
2. Background
3. scalafmt
4. Results
5. Conclusion

Overview

What is code formatting?

Unformatted

```
object     MyApp
  extends App {
  Initialize  ( context, config(port(
    "port.http"),
   settings + custom))
  Loop(  )
}
```

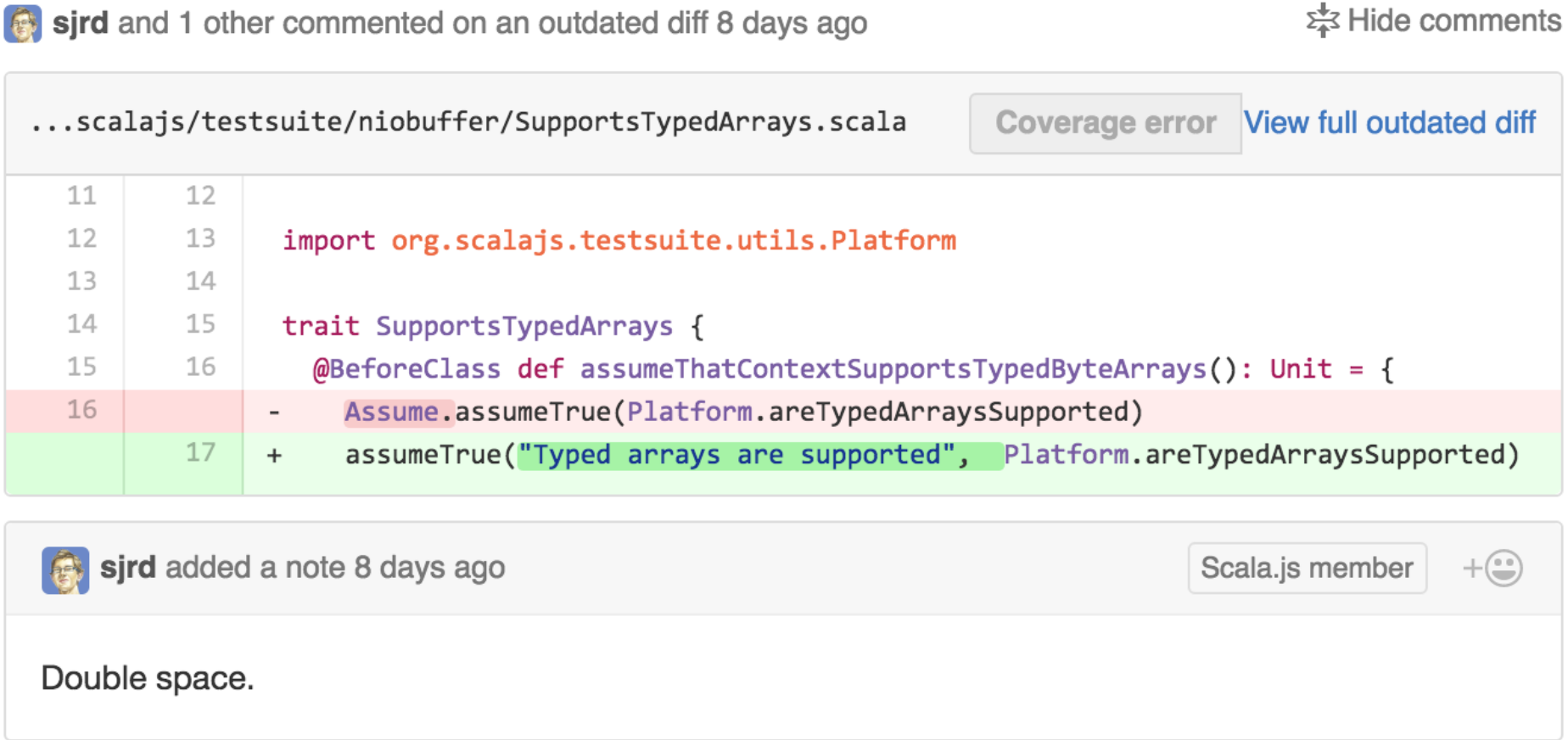
What is code formatting?

Formatted

```
object MyApp extends App {
  Initialize(
      context,
      config(port("port.http"),
             settings + custom))
  Loop()
}
```

Why?

Reason 1: Collaborative environments



Reason 2: Refactoring

Large-Scale Automated Refactoring Using

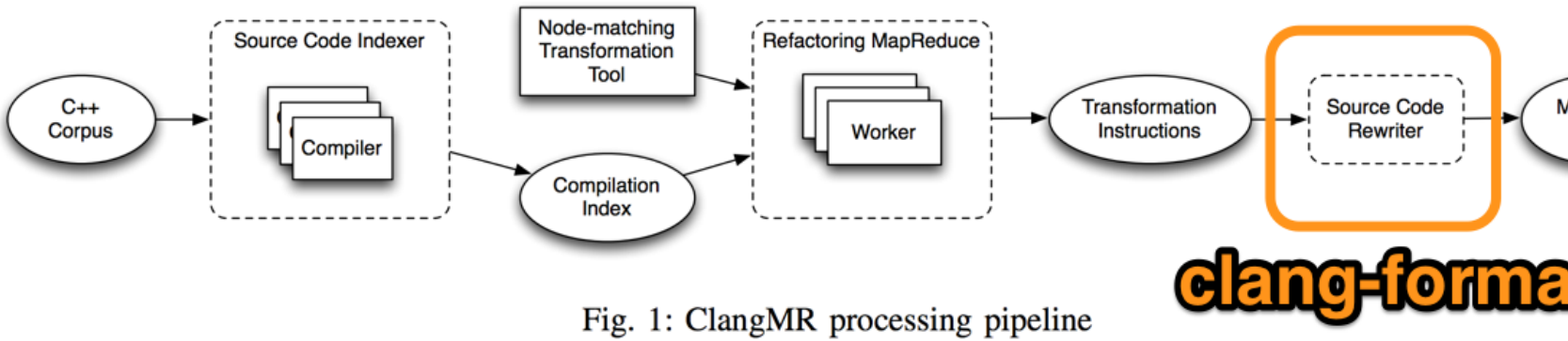


Fig. 1: ClangMR processing pipeline

ClangMR

Problem statement

What *algorithms* and *data structures* allow us to develop a Scala code formatter with the following features?

- *Maximum line length setting*
- *Opinionated setting*
- *Vertical alignment*
- *Good performance*

Maximum line length setting

```
// 40 character max line length          |
object MyApp extends App {
  // BAD
  Initialize(context, config(port("port.http"),
    settings + custom))

  // OK
  Initialize(
      context,
      config(port("port.http"),
             settings + custom))
}
```

Opinionated setting

My definition

Disregard line breaking decisions in the original source to ensure that formatted sources follow a uniform coding style.

```
// Bin-pack
class Point(val x: Int, val y: Int,
    val z: Int)

// No bin-pack
class Point(val x: Int,
            val y: Int,
            val z: Int)
```

Vertical alignment

```
object VerticalAlignment {
  x match {
    case 1  => 1  -> 2  // first
    case 11 => 11 -> 22 // second
  }

  def name   = column[String]("name")
  def status = column[Int]("status")

  libraryDependencies ++= Seq(
    "org.scala-lang" % "scala-compiler" % "2.11.7",
    "com.lihaoyi"    %% "sourcecode"    % "0.1.1"
  )
}
```

Performance

- IDEs: reformat file on save
- Build tools: reformat file on compile
- Continuous integration: reformat diff before code review

Overview

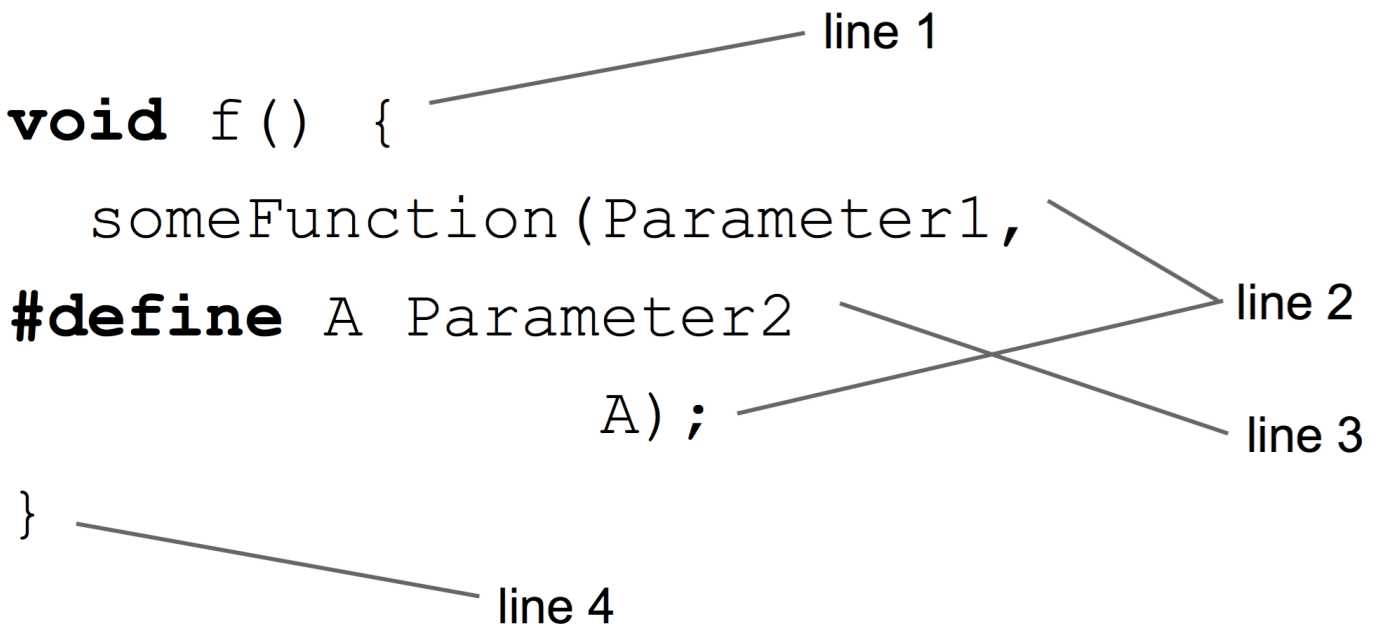
Scalariform

- No maximum line length setting
- No opinionated setting

ClangFormat

Parser

- Custom *UnwrappedLine* parser for C, C++, Objective-C, Java, JavaScript and Protobuf
  - handles invalid code
  - ∼4.000 LOC



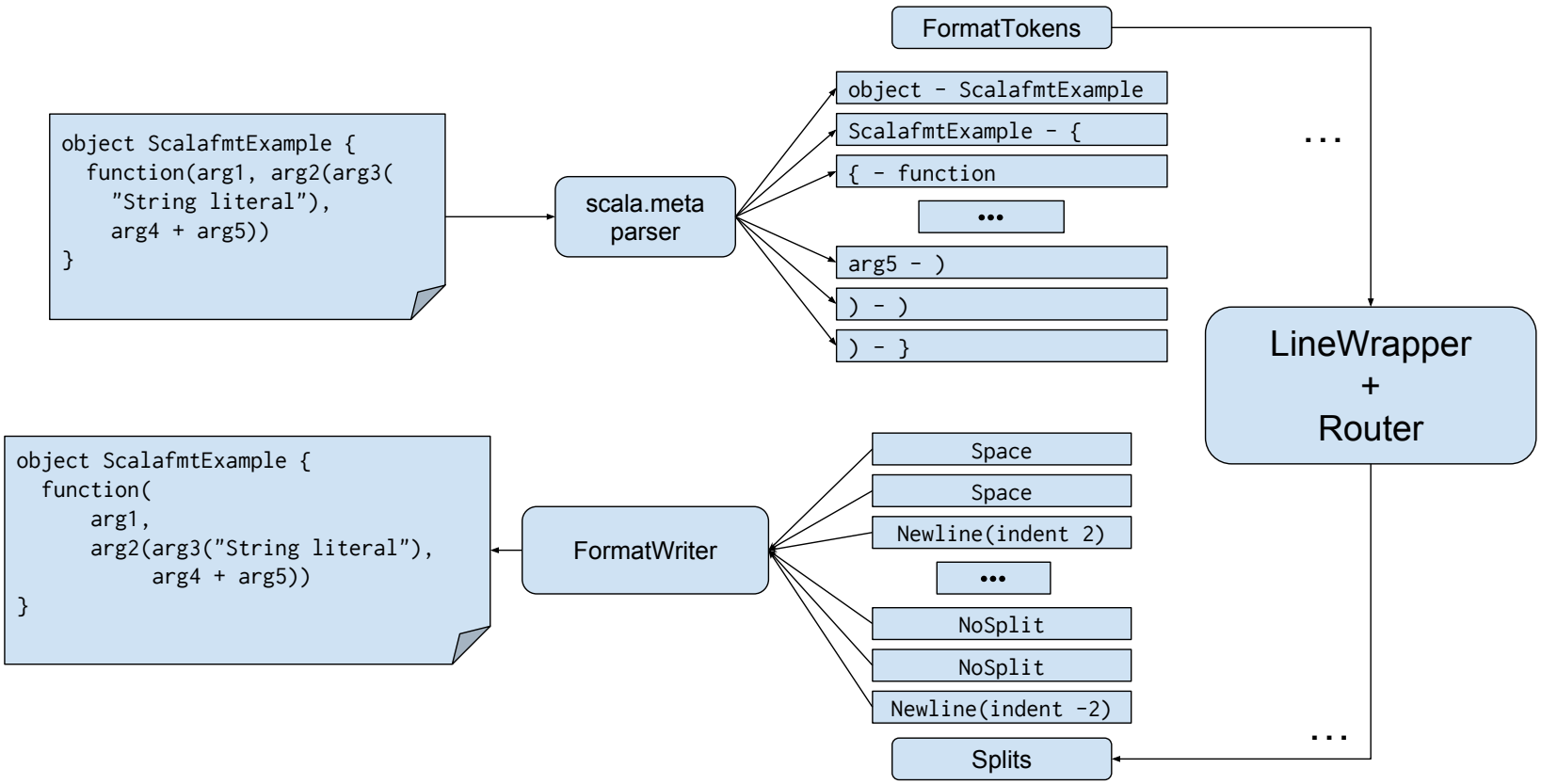
Line breaking: shortest path search

- Dijkstra's shortest path for optimal line breaking.
  - Non-whitespace tokens are nodes
  - Whitespace tokens are edges

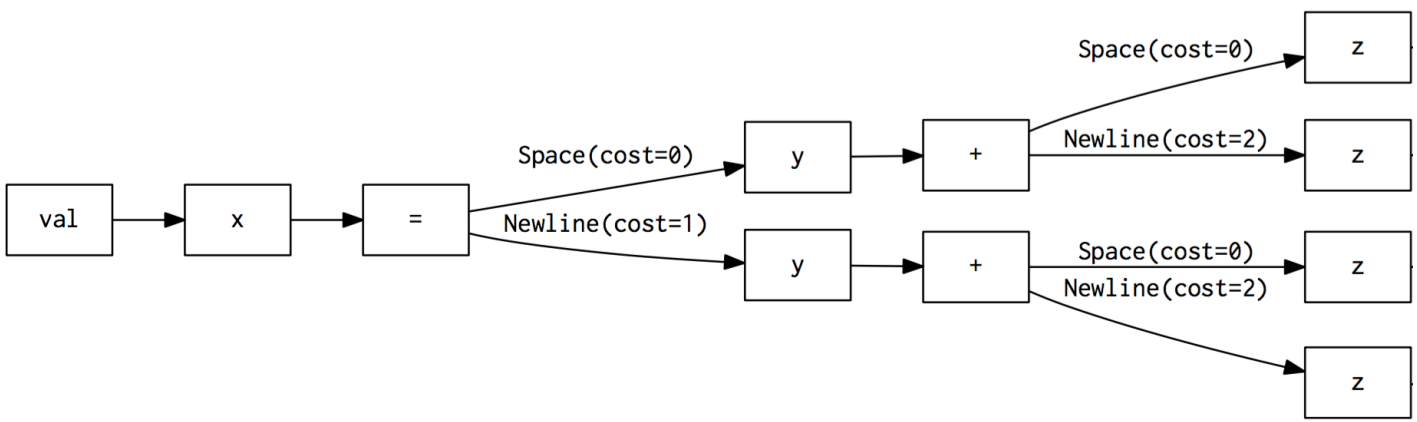
```
aaaaaaaa(aaaaaaaaaaaaa, aaaaaaaaaaaaaaa(aaaaaaaaaaaaaaaaaaaaaaaaaaaa(   Penalty: 100
                              aaaaaaaaaaaaaaaaaaaaaaaaaaaaaaaaaaaaaa)),   Penalty:  41
         aaaaaaaa(aaaaaaaaaaaaaaaaaaaaaaaaaaaaaaa(                       Penalty: 100
             aaaaaaaaaaaaaaaaaaaaaaaaaaaaaaaaaaaaaaaaaaaaaaaaaaaaaa)));  Total:   241
```

Overview

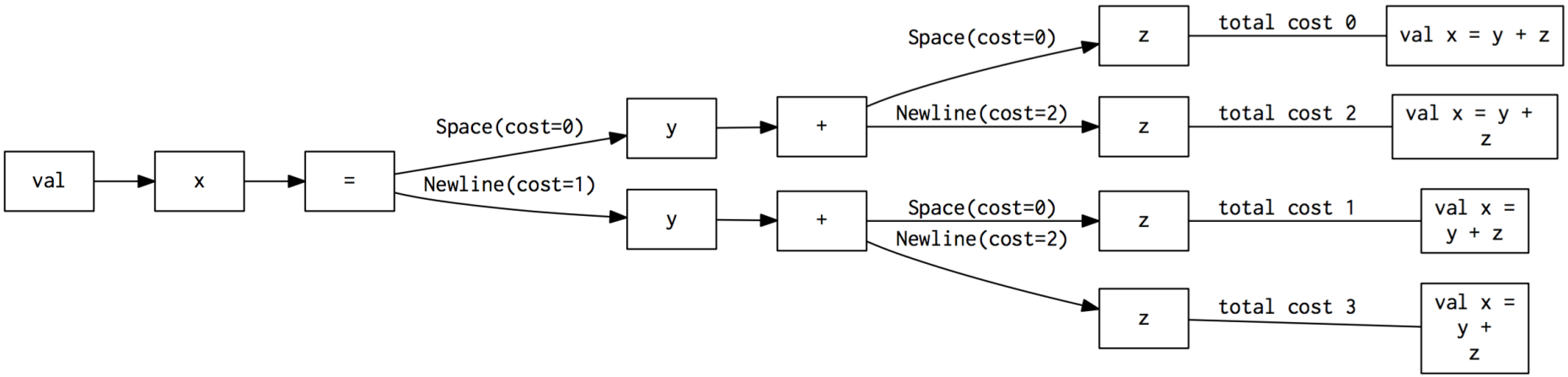
Architecture



LineWrapper + Router: val x = y + z



LineWrapper + Router: val x = y + z



Router

- One big pattern match on pairs of tokens

```
case FormatToken(_: Keyword, _) => Seq(Split(Space, 0))
case FormatToken(_, _: `=`)     => Seq(Split(Space, 0))
case FormatToken(_: `=`, _)     => Seq(Split(Space, 0)
                                       Split(Newline, 1))
// ...
```

Naïve best-first search

- Small: $\sim$ 20 LOC
- Exponential running time for basic programs

Optimization 1: dequeueOnNewStatements

```
def x = {
  function1(argument1, argument2, argument3)
  function2(argument1, argument2, argument3)
}
```

Optimization 2: OptimalToken

```
Database(UserObject(name1, age1),
         UserObject(name2, age2),
         // ...
         UserObject(nameN, ageN))
```

Optimization 3: escapeInPathologicalCases

- Give up, default behavior
- Best-effort, `-bestEffortInDeeplyNestedCode`

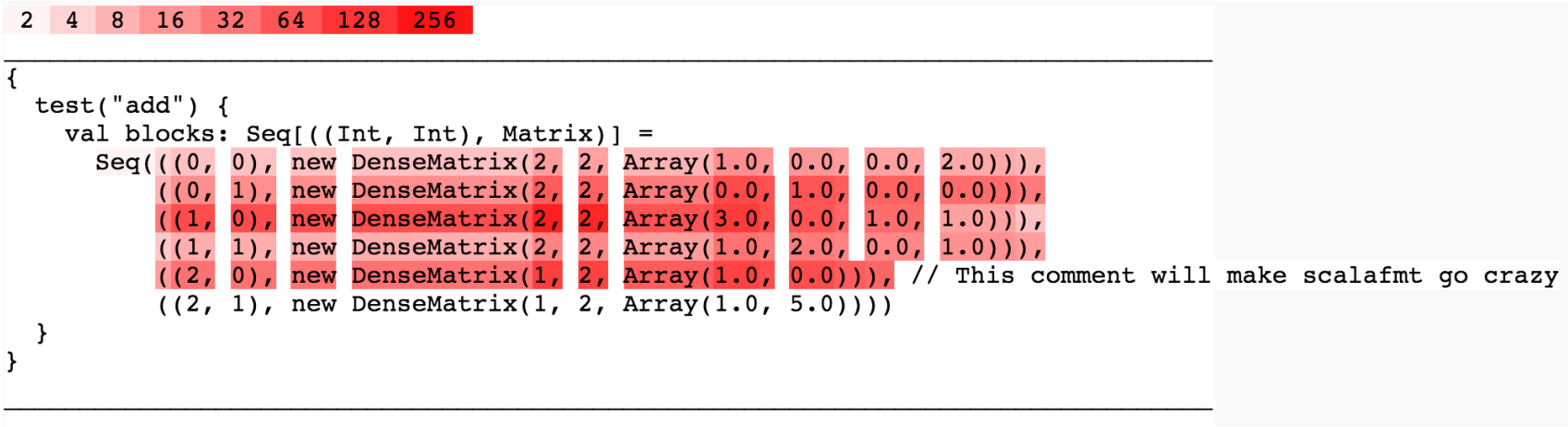
```
Defn.Object(Nil, Term.Name("State"), Template(Nil,
    Seq(Ctor.Ref.Name("Logger")), Term.Param(Nil,
    Name.Anonymous(), None, None),
    Some(Seq(Defn.Val(Nil,
    Seq(Pat.Var.Term(Term.Name("start")))), None,
    Term.Apply(Term.Name("State"), Seq()))),
    Defn.Def( /* ... */)))))
```

Summary: algorithms

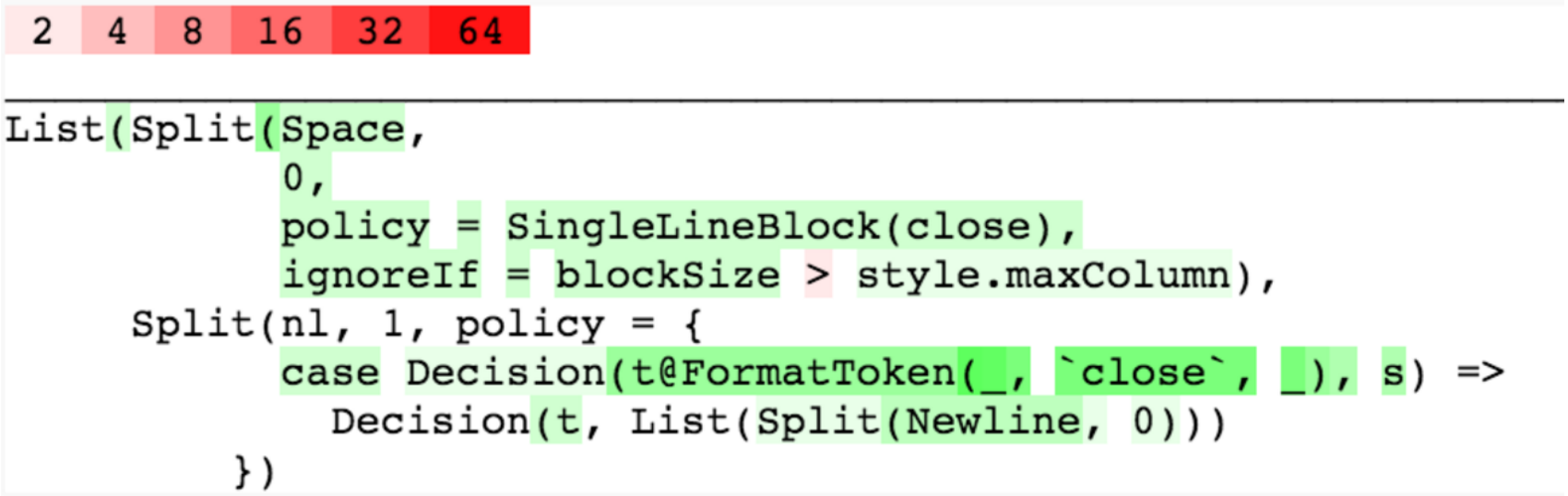
Component	Lines of code
Router	1.070
FormatWriter	175
Best-first search	369
Utilities and data structures	1.547
Total	3.161

Tooling

Heatmap


2 4 8 16 32 64 128 256
{
test("add") {
val blocks: Seq[((Int, Int), Matrix)] =
Seq(((0, 0), new DenseMatrix(2, 2, Array(1.0, 0.0, 0.0, 2.0))),
((0, 1), new DenseMatrix(2, 2, Array(0.0, 1.0, 0.0, 0.0))),
((1, 0), new DenseMatrix(2, 2, Array(3.0, 0.0, 1.0, 1.0))),
((1, 1), new DenseMatrix(2, 2, Array(1.0, 2.0, 0.0, 1.0))),
((2, 0), new DenseMatrix(1, 2, Array(1.0, 0.0))), // This comment will make scalafmt go crazy
((2, 1), new DenseMatrix(1, 2, Array(1.0, 5.0))))
}
}

Diff heatmap



Testing?

Property 1: can format

```
forAll { code =>
  whenever(scalaCompilerCanParse(code)) {
    format(code).isInstanceOf[Success]
  }
}
```

Property 2: AST integrity

```
forAll { code =>
  ast(code) structuralEquals ast(format(code))
}
```

Property 3: idempotent

```
forAll { code =>
  format(code) == format(format(code))
}
```

Demo

Overview

Macro benchmark

Insight

How does scalafmt perform in a continuous integration setup?

Task

Format Scala.js repo.

Macro benchmark

Benchmark	Cores	Score	Error	Units
Parallel.scalafmt	4	14.616	0.632	s/op
Parallel.scalariform	4	2.810	0.641	s/op
Ratio		5.20		
Synchronous.scalafmt	1	35.654	0.459	s/op
Synchronous.scalariform	1	5.951	0.135	s/op
Ratio		5.99		

Micro benchmark

Insight

How does scalafmt perform in an interactive software developer workflow?

Task

Format single source file.

File sizes

Table: Lines of code per source file. Collected from sample of ∼27.000 source files with total 3.2 million lines of code.

25th	Median	Mean	75th	90th	95th	99th	Max
16	46	106	113	248	400	945	11.723

- Small: ∼ 50 LOC
- Medium: ∼ 300 LOC
- Large: ∼ 1.000 LOC
- Extra large: ∼ 4.500 LOC

Micro benchmark: results

Benchmark	Score	Error	Units
$\sim$ 50 LOC			
Small.scalafmt	6.968	0.104	ms/op
Small.scalariform	1.176	0.025	ms/op
Ratio	5.93		
$\sim$ 300 LOC			
Medium.scalafmt	79.616	2.013	ms/op
Medium.scalariform	15.934	0.441	ms/op
Ratio	5.00		

Micro benchmark: results

Benchmark	Score	Error	Units
$\sim$ 1000 LOC			
Large.scalafmt	355.819	17.385	ms/op
Large.scalariform	39.324	3.395	ms/op
Ratio	9.05		
$\sim$ 4500 LOC			
ExtraLarge.scalafmt	1423.140	103.360	ms/op
ExtraLarge.scalariform	219.820	14.450	ms/op
Ratio	6.50		

Installations

Table: Download numbers for scalafmt

Channel	Version	Installations
IntelliJ	v0.2.5	847
	All	3.273
Maven	v0.2.5	788
	All	2.657
Github	v0.2.5	102
	All	929
Sum	v0.2.5	1.737
	All	6.859

Installations

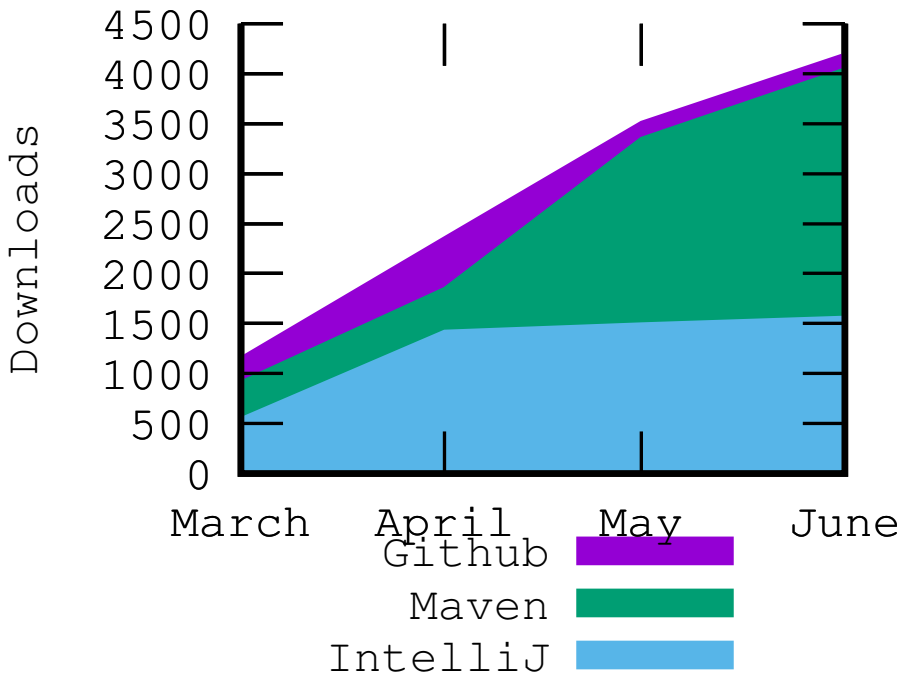


Figure: Scalafmt installations by month by channel

Miscellanea

- Libraries that have reformatted their codebase with scalafmt:
  - scala-native
  - scala-js-dom[1]
  - psp-std
  - fetch
  - ...
- 9 contributors to code and documentation
- 34 users have reported 138 issues on Github
- 66 members in Gitter channel
- 7.469 visits to documentation with 1min 48s avg visit time
- 3 conferences where scalafmt was presented

[1] With a bit of manual help

Verizon

“Verizon is now including scalafmt (with reformat on compile settings) in the default template for all new projects (which, in a sizable microservices shop, is a lot of projects)
thanks for an awesome tool!”

— Daniel Spiewak

Overview

Conclusions

Maximum line length setting	✓
Opinionated settings	✓
Vertical alignment	✓
Performance	?[2]

[2] 6x slower than scalariform, but that seems OK for many users

The End

Thank you!