

Staging Parser Combinators for Efficient Data Processing

Parsing @ SLE, 14 September 2014

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What are they good for?

- Composable
 - Each combinator builds a new parser from a previous one
- Context-sensitive
 - We can make decisions based on a specific parse result
- Easy to Write
 - DSL-style of writing
 - Tight integration with host language

Example: HTTP Response

HTTP/1.1 200 OK

Date: Mon, 23 May 2013 22:38:34 GMT

Server: Apache/1.3.3.7 (Unix) (Red-Hat/Linux)

Last-Modified: Wed, 08 Jan 2012 23:11:55 GMT

Etag: "3f80f-1b6-3e1cb03b"

Content-Type: text/html; charset=UTF-8

Content-Length: 129

Connection: close

... payload ...

Example: HTTP Response

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Status

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Connection: close

Headers

... payload ...

Content

Example: HTTP Response

```
def status = ( ("HTTP/" ~ decimalNumber) ~> wholeNumber <~ (text ~ crlf)
) map ( _.toInt )
```

Transform parse results on the fly

Example: HTTP Response

```
def status = ( ("HTTP/" ~ decimalNumber) ~> wholeNumber <~ (text ~ crlf)
) map (_.toInt)
def header = (headerName <~ ":") flatMap {
  key => (valueParser(key) <~ crlf) map {
    value => (key, value)
  }
}
```

Transform parse results on the fly

Make decision based on parse result

Example: HTTP Response

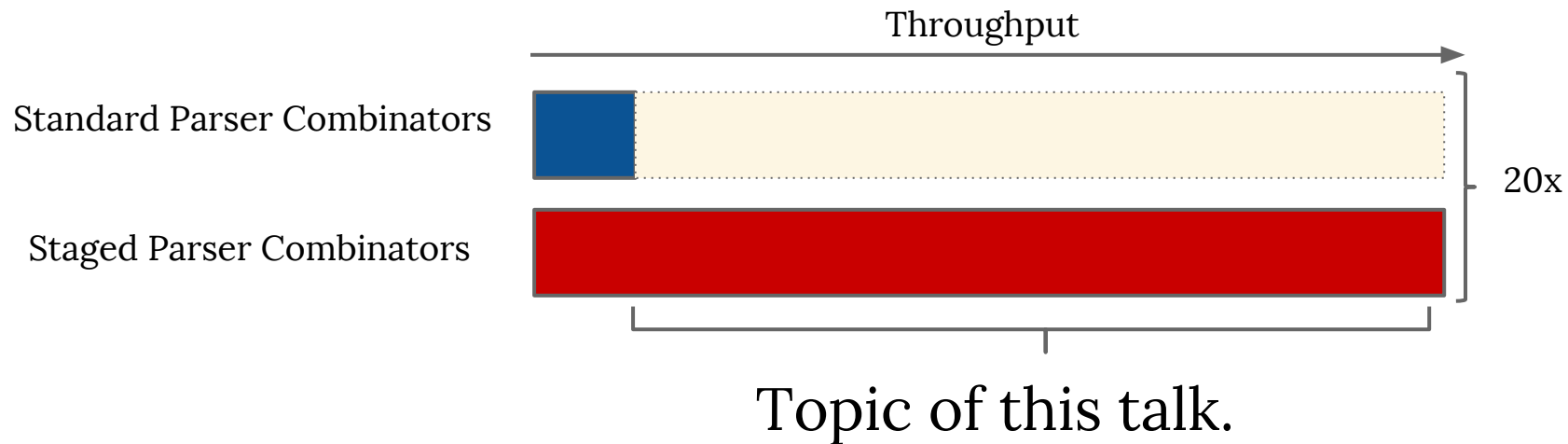
```
def status = ( ("HTTP/" ~ decimalNumber) ~> wholeNumber <~ (text ~ crlf)
) map (_.toInt)
def header = (headerName <~ ":") flatMap {
  key => (valueParser(key) <~ crlf) map {
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  }
}
def respWithPayload = response flatMap {
  r => body(r.contentLength)
}
```

Transform parse results on the fly

Make decision based on parse result

Make decision based on parse result

Parser combinators are slow



Parser Combinators are slow

```
def status: Parser[Int] = ( ("HTTP/" ~ decimalNumber) ~> wholeNumber <~ (text ~
  crlf)
  ) map (_.toInt)
def header = (headerName <~ ":") flatMap {
  key => (valueParser(key) <~ crlf) map {
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`class Parser[T] extends (Input => ParseResult[T]) ...`

Parser Combinators are slow

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    value => (key, value)  
  }  
}  
def respWithPayload = response flatMap {  
  r => body(r.contentLength)  
}
```

class Parser[T] extends (Input => ParseResult[T]) ...

def ~[U](that: Parser[U]) =
 new Parser[(T,U)] {
 def apply(i: Input) = ...
 }

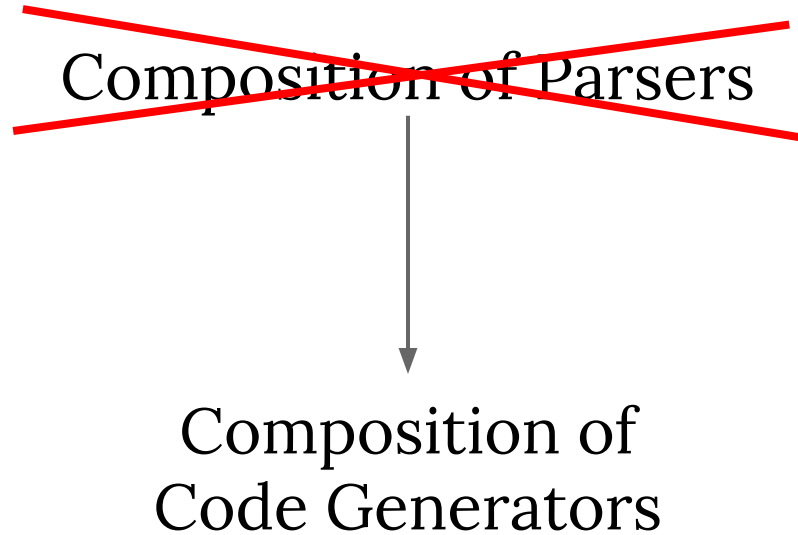
Parser Combinators are slow

- Prohibitive composition overhead
- **But:** composition is mostly static
 - Let us systematically remove it!

Staged Parser Combinators

Composition of Parsers

Staged Parser Combinators



Staging (LMS)

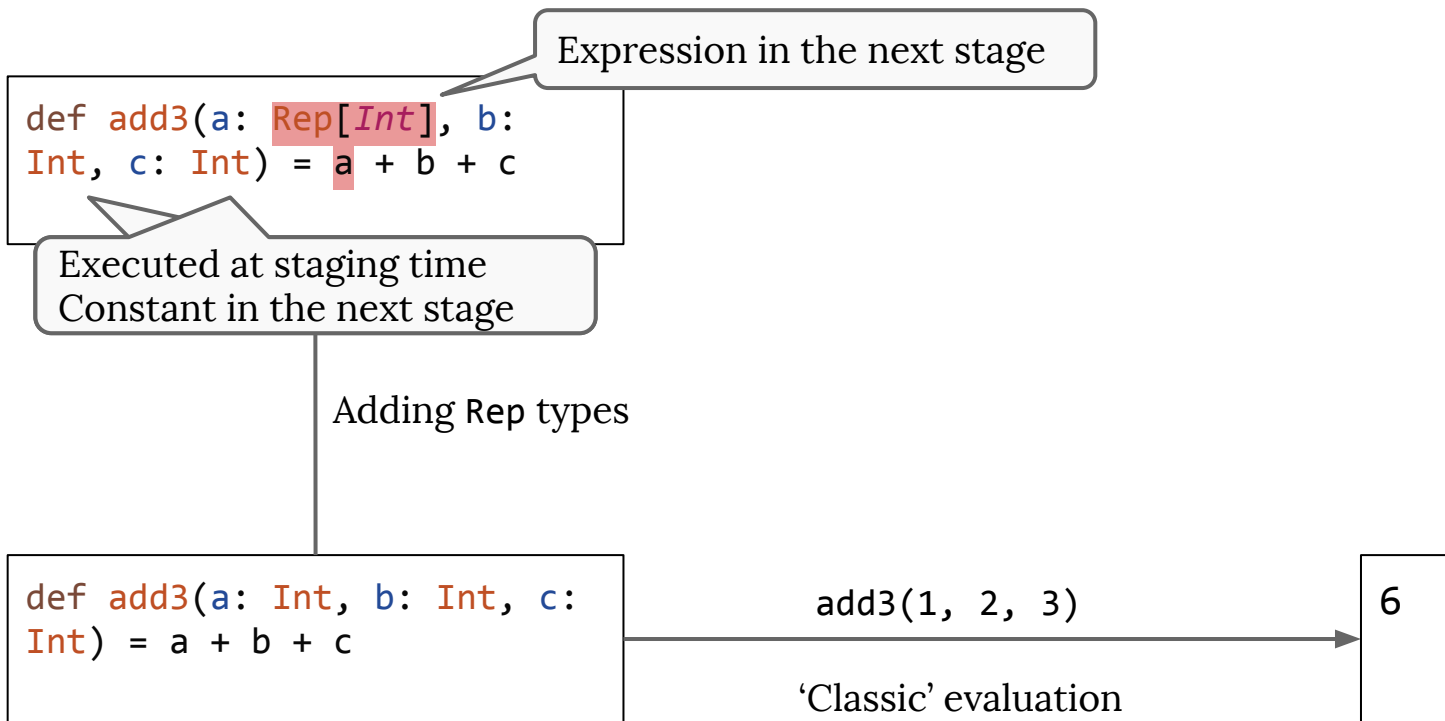
```
def add3(a: Int, b: Int, c:  
Int) = a + b + c
```

add3(1, 2, 3)

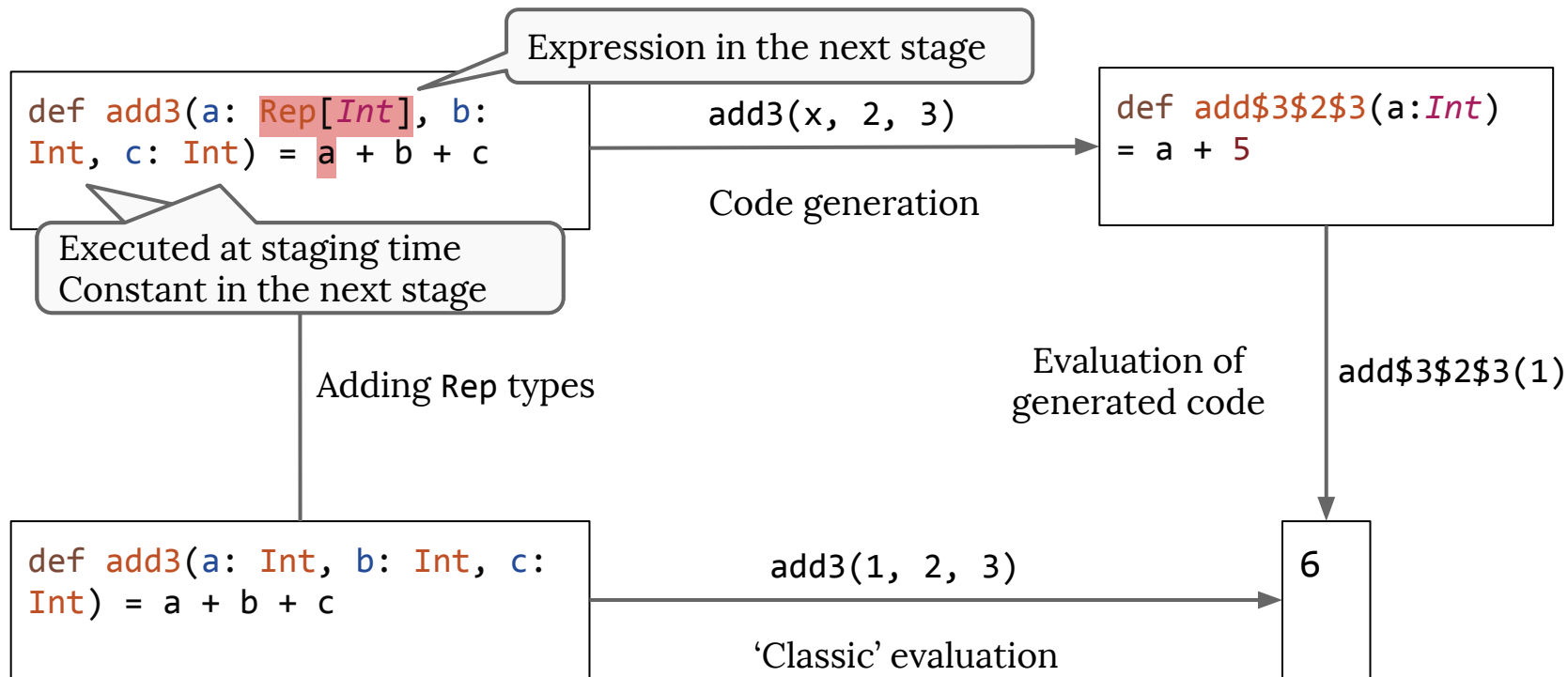
'Classic' evaluation

6

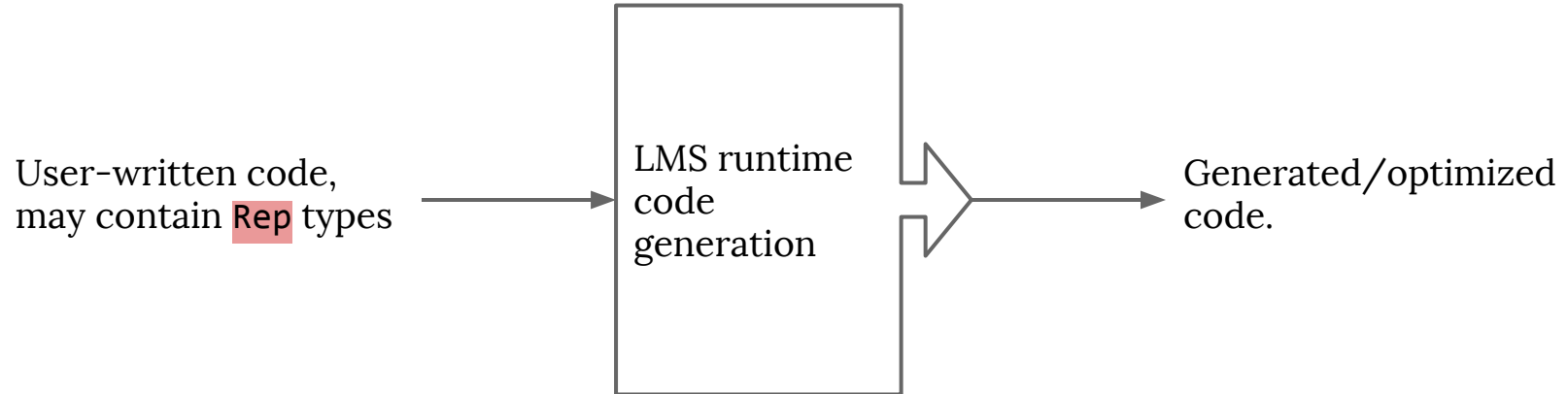
Staging (LMS)



Staging (LMS)



LMS



Staging Parser Combinators

Composition of Code Generators

```
class Parser[T] extends  
(Input => ParseResult  
[T])
```



```
class Parser[T] extends  
(Rep[Input] => Rep[ParseResult[T]])
```

dynamic input/output

static function: application == inlining for free

Staging Parser Combinators

Composition of Code Generators

```
class Parser[T] extends  
(Input => ParseResult  
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```

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class Parser[T] extends  
(Rep[Input] => Rep[ParseResult[T]])
```

dynamic input/output

static function: application == inlining for free

```
def ~[U](that: Parser  
[U])
```

```
def ~[U](that: Parser  
[U])
```

still a code generator

```
def map[U](f: T => U): Parser  
[U]
```

```
def map[U](f: Rep[T] => Rep[U]): Parser[U]
```

Staging Parser Combinators

Composition of Code Generators

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class Parser[T] extends  
(Input => ParseResult  
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class Parser[T] extends  
(Rep[Input] => Rep[ParseResult[T]])
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dynamic input/output

static function: application == inlining for free

```
def ~[U](that: Parser  
[U])
```

```
def ~[U](that: Parser  
[U])
```

still a code generator

```
def map[U](f: T => U): Parser  
[U]
```

```
def map[U](f: Rep[T] => Rep[U]): Parser[U]
```

```
def flatMap[U](f: T => Parser[U])  
: Parser[U]
```

```
def flatMap[U](f: Rep[T] => Parser  
[U])  
: Parser[U]
```

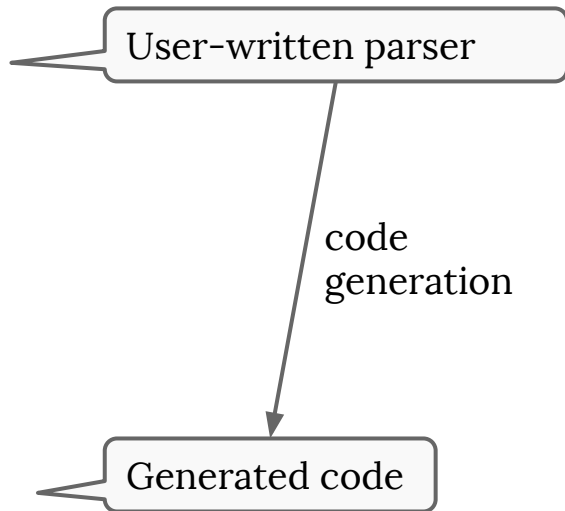
still a code generator

A closer look

```
def respWithPayload: Parser[..] =  
  response flatMap {  
    r => body(r.contentLength)  
  }
```



```
// code for parsing response  
val response = parseHeaders()  
val n = response.contentLength  
//parsing body  
var i = 0  
while (i < n) {  
  readByte()  
  i += 1  
}
```



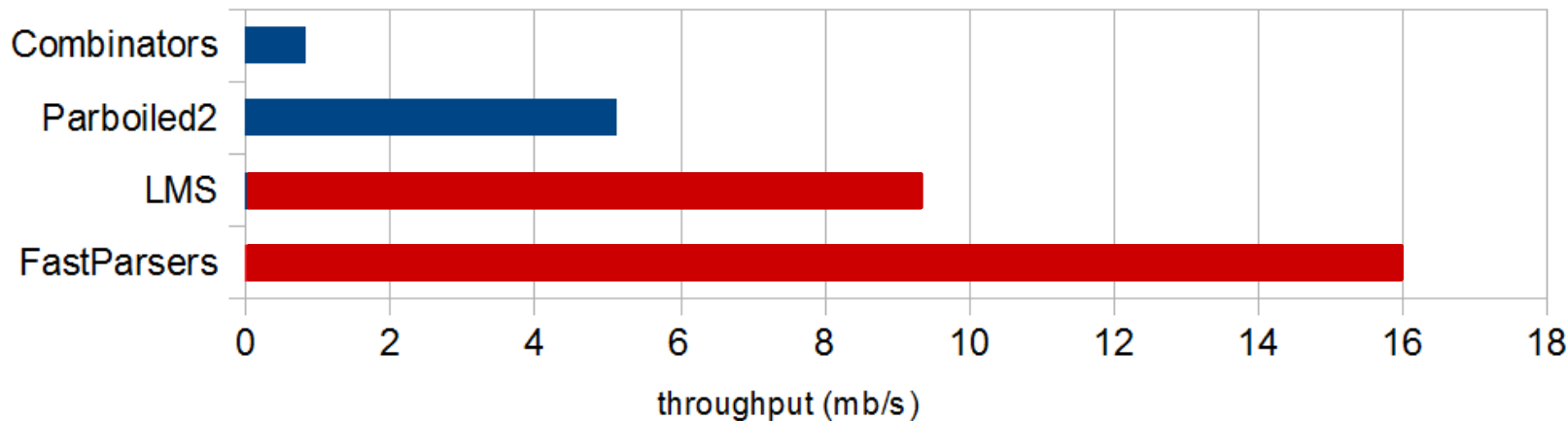
Gotchas

- Recursion
 - explicit recursion combinator (fix-point like)
- Diamond control flow
 - code generation blowup

General solution

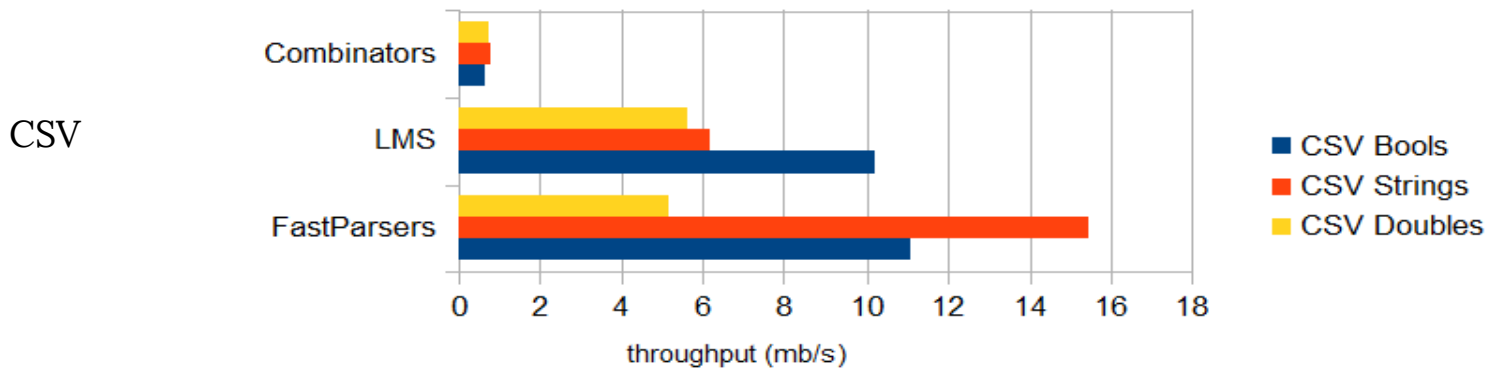
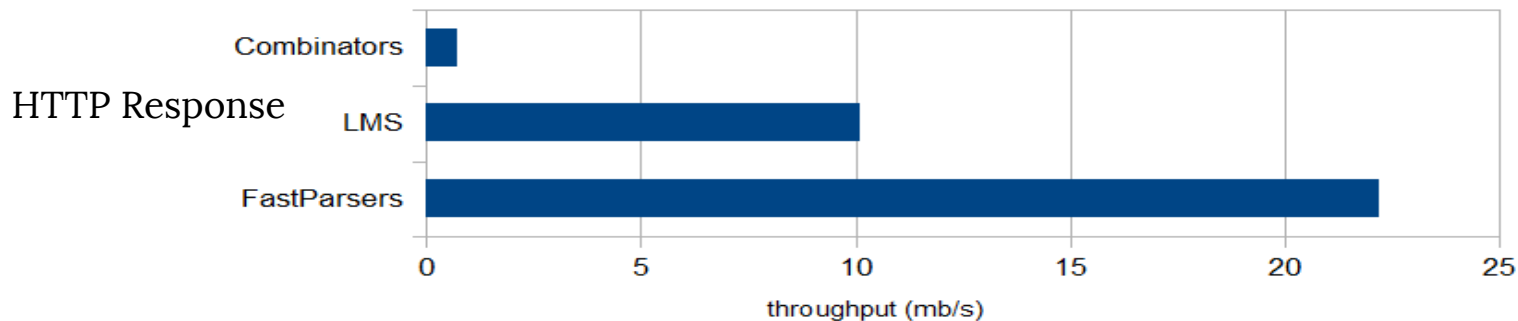
- generate staged functions (`Rep[Input => ParseResult]`)

Performance: Parsing JSON



- 20 times faster than Scala's parser combinators
- 3 times faster than Parboiled2


Performance



If you want to know more

- Parser Combinators for Dynamic Programming [OOPSLA '14]
 - based on ADP
 - code gen for GPU
- Using Scala Macros [Scala '14]

Desirable Parser Properties

	Hand-written	Parser Generators	Staged Parser Combinators
Composable	×	✓	✓
Customizable	×	×	✓
Context-Sensitive	✓	~	✓
Fast	✓	✓	
Easy to write	×	✓	✓

The people

- Eric Béguet
- Sandro Stucki
- Thierry Coppey
- Tiark Rompf
- Martin Odersky

Tack!

Fråga?

Staging all the way down

- Staged structs
 - boxing of temporary results eliminated
- Staged strings
 - substring not computed all the time

Optimizing String handling

```
class InputWindow[Input](val in: Input, val start: Int, val end: Int){  
  override def equals(x: Any) = x match {  
    case s : InputWindow[Input] =>  
      s.in == in &&  
      s.start == start &&  
      s.end == end  
    case _ => super.equals(x)  
  }  
}
```

Key performance impactors

Standard Parser Combinators



Beware!

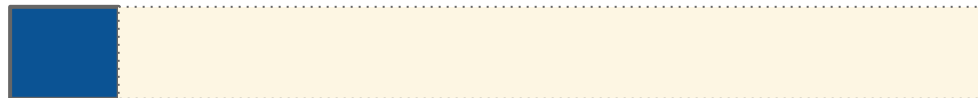
- `String.substring` is in linear time (\geq Java 1.6).
- Parsers on Strings are inefficient.
- Need to use a `FastCharSequence` which mimics original behaviour of `substring`.

Key performance impactors

Standard Parser Combinators

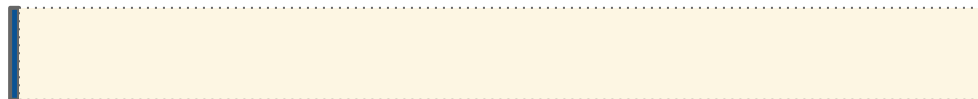


Standard Parser Combinators
with FastCharSequence

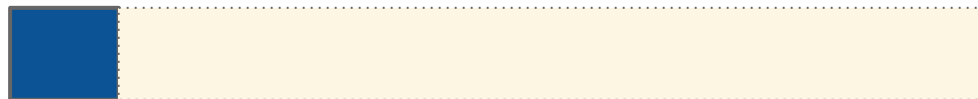


Key performance impactors

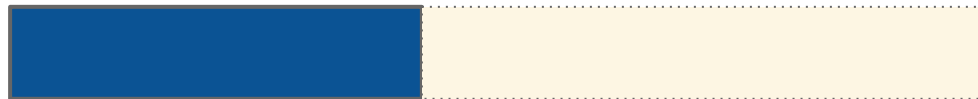
Standard Parser Combinators



Standard Parser Combinators with FastCharSequence

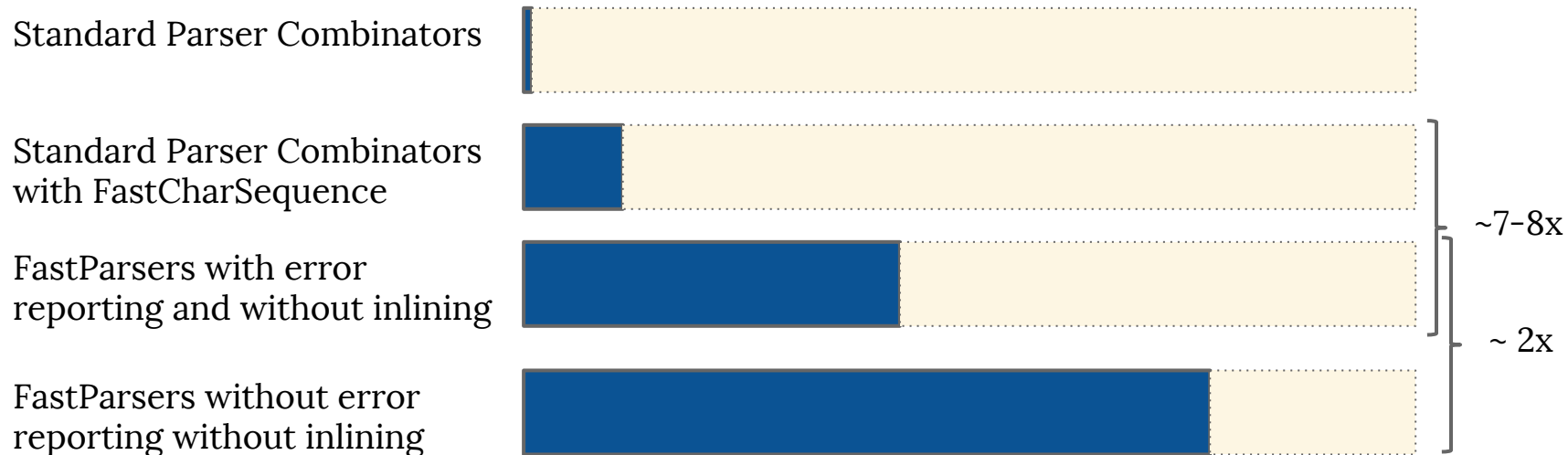


FastParsers with error reporting and without inlining



~7-8x

Key performance impactors



Key performance impactors

