

# Parsing Challenges in Java 8

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Erik Hogeman, Jesper Öqvist, Görel Hedin

Department of Computer Science

Lund University



JastAddJ is a full source-to-bytecode modular Java compiler

- each Java version is a separate module
- Java 8 was implemented by Erik Hogeman for his Master's Thesis
- this talk is about the parsing challenges encountered

## Noteworthy features:

- Lambdas
- Method references
- Default methods

Java finally has anonymous functions!

$(x, y) \rightarrow x + y$

$() \rightarrow \{ \text{action1}(); \text{action2}(); \}$

# Lambda Example

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Action listeners the old way:

```
button.addActionListener(new ActionListener() {  
    public void actionPerformed(ActionEvent e) {  
        print("hello");  
    }  
});
```

The new way, using lambda:

```
button.addActionListener( (e) -> print("hello") );
```



A way of using regular instance methods as lambdas:

```
Greeter greeter = new MyGreeter();  
greetButton.addActionListener( greeter::greet );  
exitButton.addActionListener( greeter::exit );
```

# Default Methods

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Interfaces can have non-abstract methods:

```
interface Greeter {  
    default void greet(ActionEvent e) {  
        print("greetings");  
    }  
    default void exit(ActionEvent e) {  
        print("goodbye");  
    }  
}  
  
class MyGreeter implements Greeter {  
    // use default implementations  
}
```



We use an LALR parser for JastAddJ

- Generated with the Beaver parser generator
- Parser grammar is composed from parts in separate modules



# Why an LR Parser Generator?

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Advantages of a generated LR parser:

- Provably fast
- Generator certifies unambiguous grammar
- Decent tool support
- Bit more powerful than LL



# Java 8 Parsing Challenges

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- Ambiguous grammar specification
- Reduce-reduce conflicts between subexpressions
- Shift-reduce conflict
- Unlimited lookahead



# Ambiguous Grammar Specification

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Java spec (highly edited):

Expression  $\rightarrow$  Lambda

Expression  $\rightarrow$  ...  $\rightarrow$  Additive

$\rightarrow$  Multiplicative  $\rightarrow$  ...  $\rightarrow$  Cast

Cast  $\rightarrow$  (Type) Lambda

Input:

(T) (a, b)  $\rightarrow$  a \* b;

Possible parse 1:

((T) (a, b)  $\rightarrow$  a) \* b;

Possible parse 2:

(T) ((a, b)  $\rightarrow$  a \* b);



The second one is desired. We achieved this by:

- changed the grammar
- lambda as primary expression
- lowered priority using precedence declarations



# Lambda Reduce-Reduce Conflict

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Lambda vs less-than expression:

```
(T<A> s) -> { } // lambda  
(T<A)           // less-than expression
```

This is a reduce-reduce conflict.

Similar conflict in Java 5 with type cast:

```
(T<A>) s           // generic type cast  
(T<A)             // less-than expression
```

In both cases the T terminal must be reduced to either *RelationalExpression* or *ReferenceType*.



# Lambda Reduce-Reduce Conflict

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We solved the reduce-reduce conflict by giving the related parsing productions explicit common prefixes:

Relational -> Name < Shift

Relational -> Relational < Shift

...

ReferenceType -> Name < TypeArguments\_1

This removed the need to reduce the Name token too early.



# Unlimited Lookahead

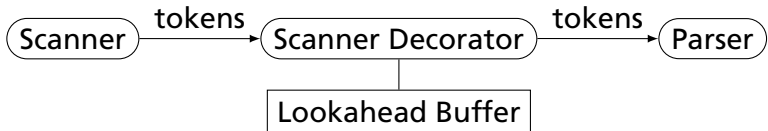
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```
f(T<A, B>::m)    // method reference  
f(T<A, B> m)     // less-than expression
```

There is no reasonable fixed lookahead that will allow the parser to decide between a less-than expression, or method reference.

# Scanner Decorator

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The Scanner Decorator looks ahead in the token stream when certain tokens are encountered, then potentially modifies the token stream.

In the previous case it inserts a synthetic `LT_TYPE` token.



# Conclusions

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- Java is not LR, but with some modifications we can make it LR(1)
- So far implemented nearly all of Java 8 features (parsing is complete)

Techniques we used to solve parsing challenges:

- Duplicate grammar to avoid reduce-reduce conflicts
- Introduce priority declarations to fix ambiguous grammar
- Scanner decorator to enable infinite lookahead



Questions!

## Default Modifier Shift-Reduce

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We parse all modifiers using the same production (for methods, interfaces, classes).

This introduced a shift-reduce conflict in switch-statements:

```
switch (x) {  
  case 0:  
    default class A() { };  
  case 1:  
    break;  
  default:  
}
```

# Intersection Type Cast

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In Java 8 cast expressions can have the form:

`(A & B & C) x`

This form conflicts with binary expressions:

`(A & B & C)`

The conflict is very similar to the lambda versus less-than expression conflict.

## Parsing Intersection Type Casts

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We solve this conflict using the Scanner Decorator. Whenever a left-parenthesis is encountered, the decorator inserts the synthetic INTERCAST token if it determines that it is part of an intersection type cast.