Lenguajes y Sistemas Informáticos para la resolución de problemas complejos

Campus América 2019

Procesadores de Lenguajes

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- Semántica y Ambigüedad
- Esquemas de Traducción
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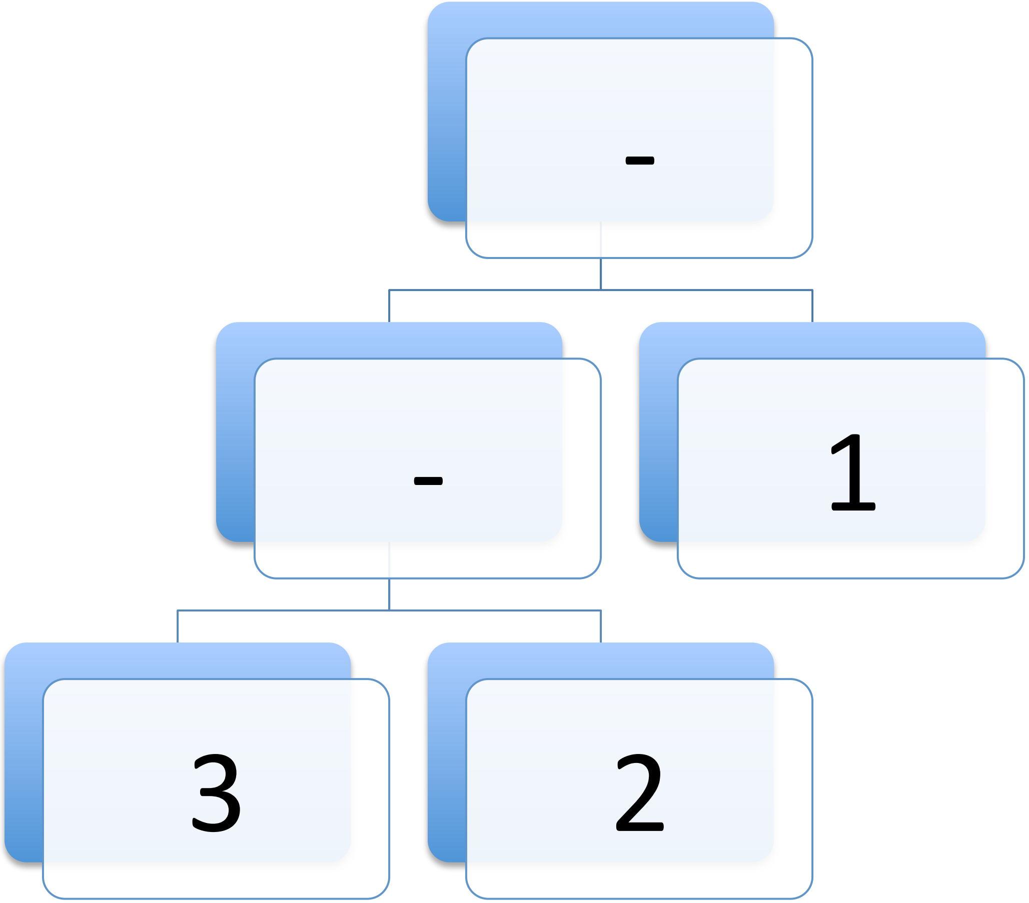
- Resolución Dinámica de Conflictos
- Recorrido del AST y Generación de Código

3 - 2 - 1

Árbol Sintáctico Abstracto

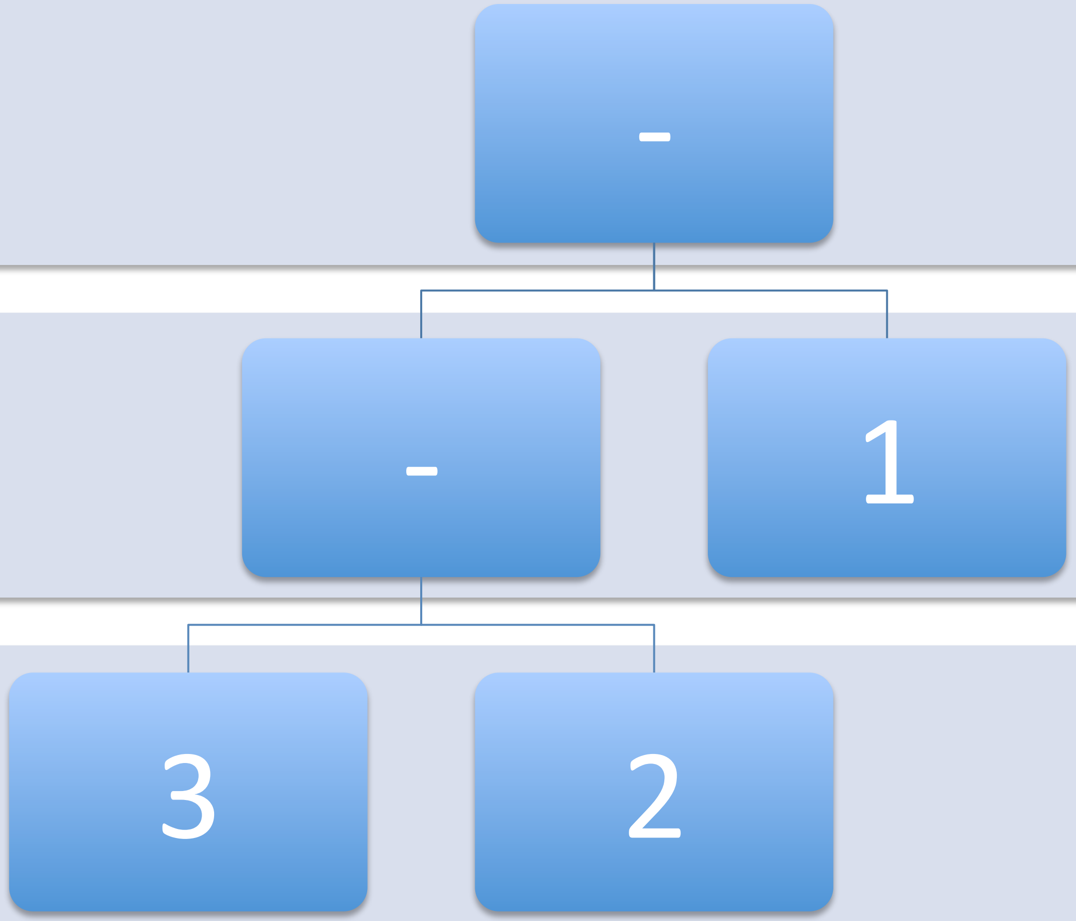
(3-2)-1



Semántica 3 - 2 - 1

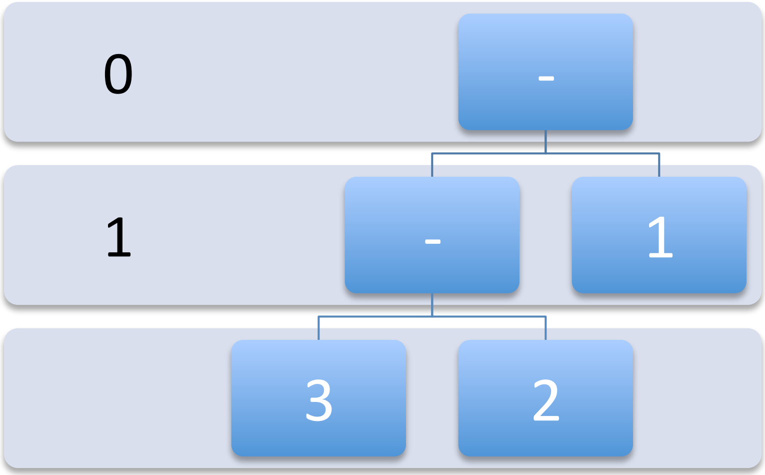
0 = 1 - 1

1 = 3 -2



Semántica y Ambigüedad

(3-2)-1



0

-

1

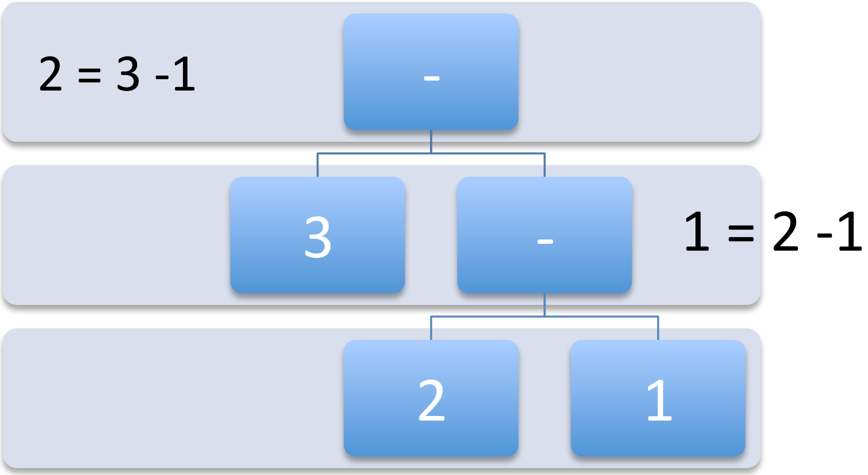
-

1

3

2

3-(2-1)



2 = 3 -1

-

3

-

1 = 2 -1

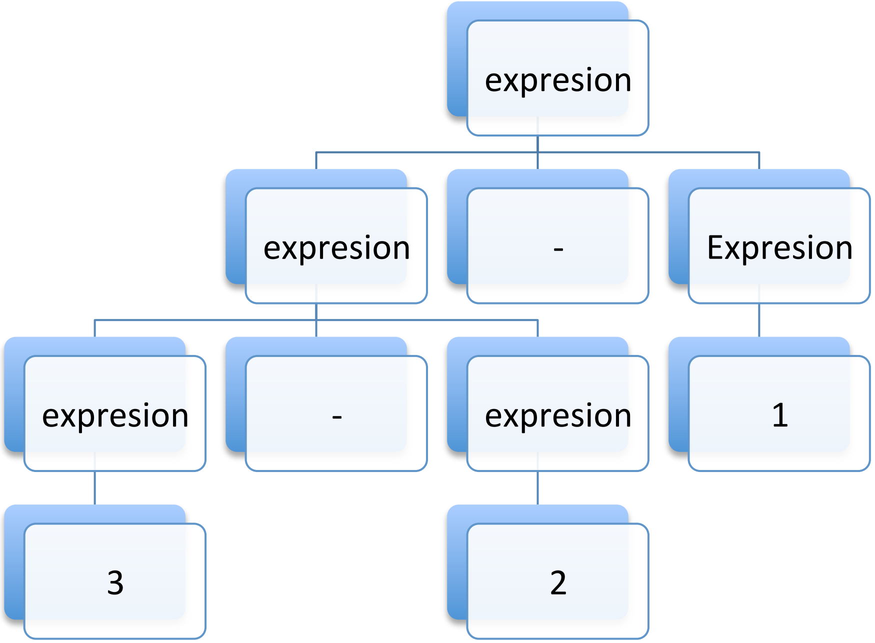
2

1

Gramática Independiente del Contexto

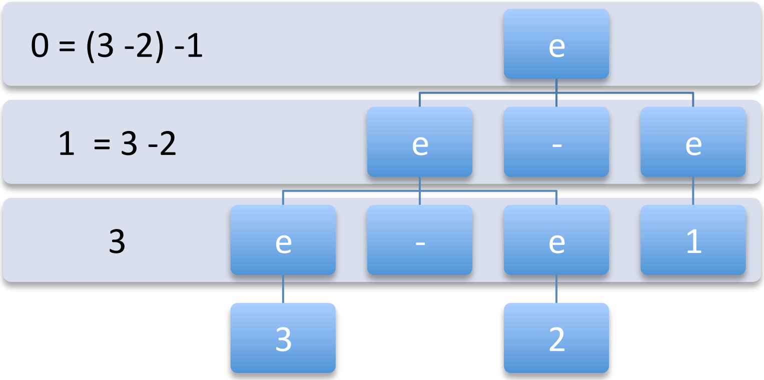
- expresion -> expresion ‘-’ expresion
- expresion -> NUMERO

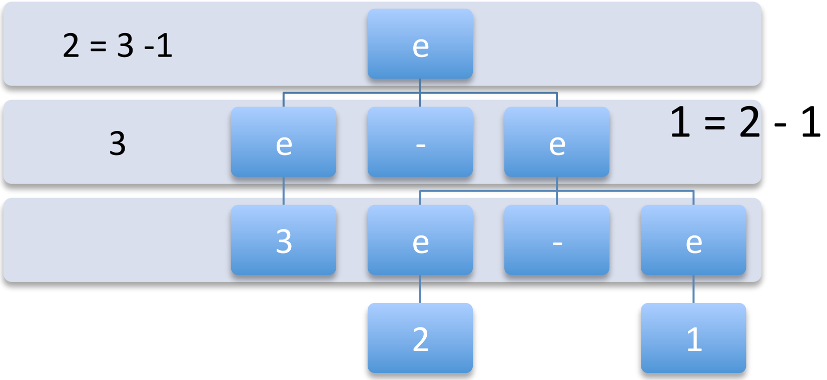
(3-2)-1



Gramática Ambigua

- expresion -> expresion '-' expresion
- expresion -> NUMERO

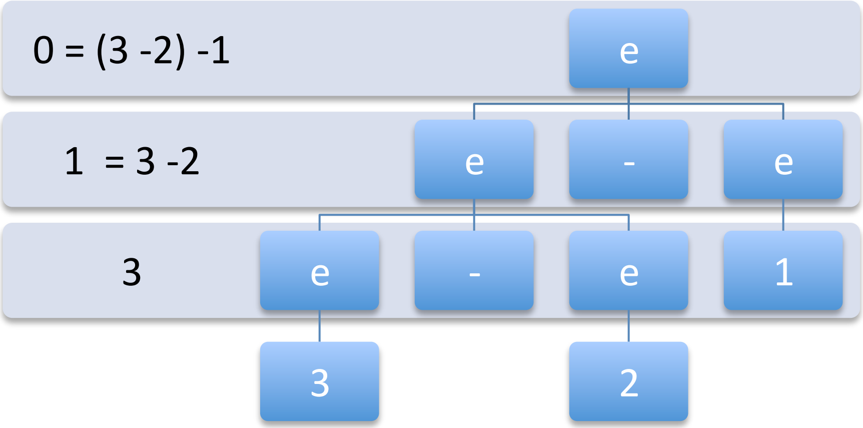


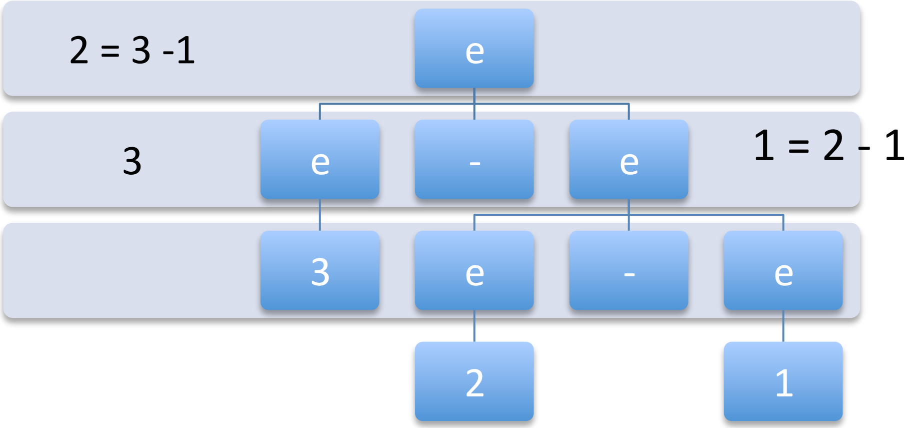


Esquema de Traducción (yacc)

```
e   -> e '-' e    { $$ =  $1 - $3;  }
e ->  NUM     { $$ = Number($1);   }
```

3 – 2 - 1





Parsing: Construcción del Árbol

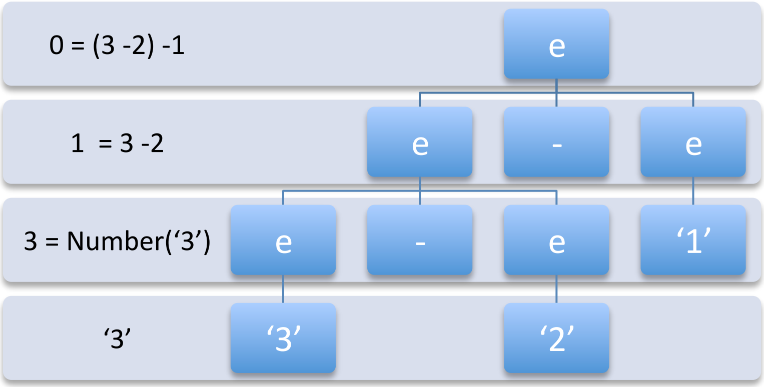
```
e   -> e '-' e    { $$ =  $1 - $3;  }
e ->  NUM     { $$ = Number($1);   }
```

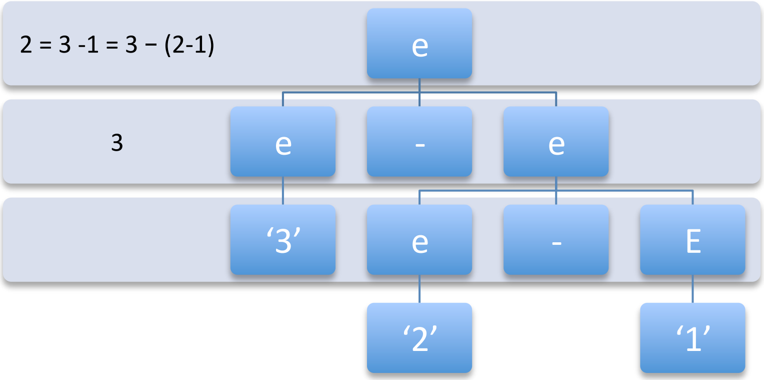
Análisis Sintáctico Ascendente:

.3 – 2 – 1 <= e. – 2 – 1 <= = e –. 2 – 1 <= = e – 2. – 1 <= e – e. – 1

¿Qué hacer?

1. <= e. – 1 <= e - . 1 <= e – 1. <= e – e. <= e.
2. <= e – e - . 1 <= e – e – 1. <= e – e – e. <= e – e. <= e.





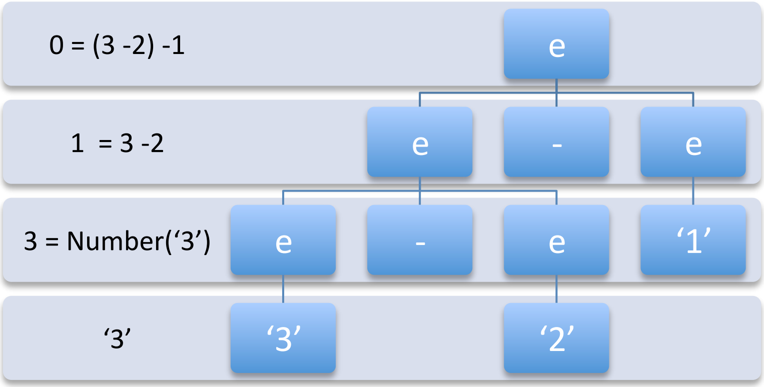
Conflicto Shift/Reduce

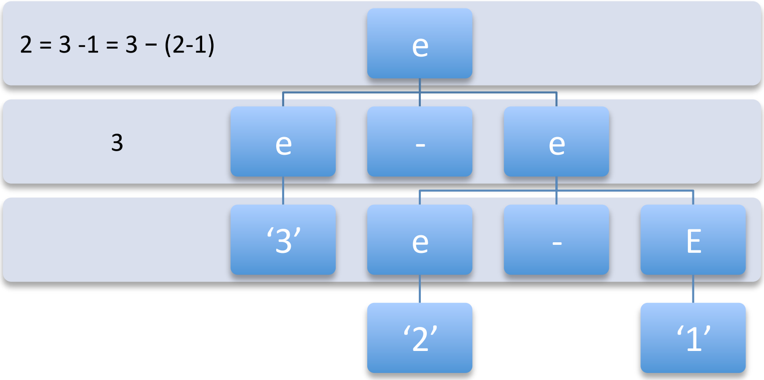
.3 – 2 – 1 <= e. – 2 – 1 <= = e –. 2 – 1 <= = e – 2. – 1 <= e – e. – 1

¿Qué hacer?

1. <= e. – 1 <= e - . 1 <= e – 1. <= e – e. <= e.
2. <= e – e - . 1 <= e – e – 1. <= e – e – e. <= e – e. <= e.

El conflicto puede verse como una lucha entre la regla e -> e '-' e y el terminal/token '-'





Un programa Yacc

```
%left  ‘–’
```

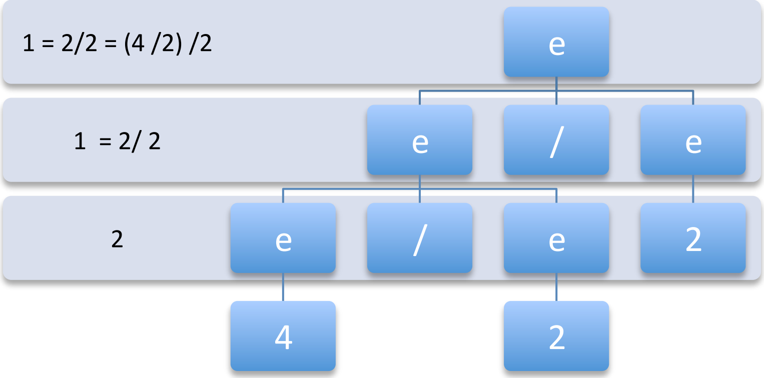
← **En la lucha entre la regla e -> e ‘-’ e y el terminal/token ‘-’ debe “ganar” la regla**

```
%%
s   :  e            { return $1; }
    ;

e   : e ‘–‘e { $$ = $1 - $3; }
     | NUM  { $$ = Number($1); }
     ;
```

Ambigüedad: Asociatividad
4/2/2

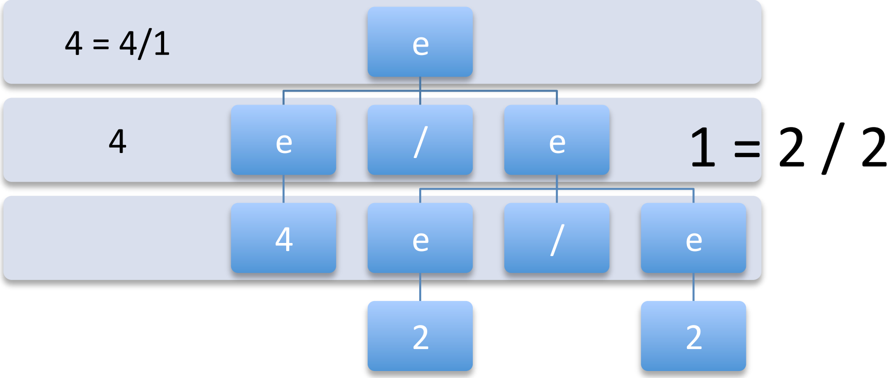
(4/2)/2

4/((2/2)


1 = 2/2 = (4 /2) /2

1 = 2/ 2

2


4 = 4/1

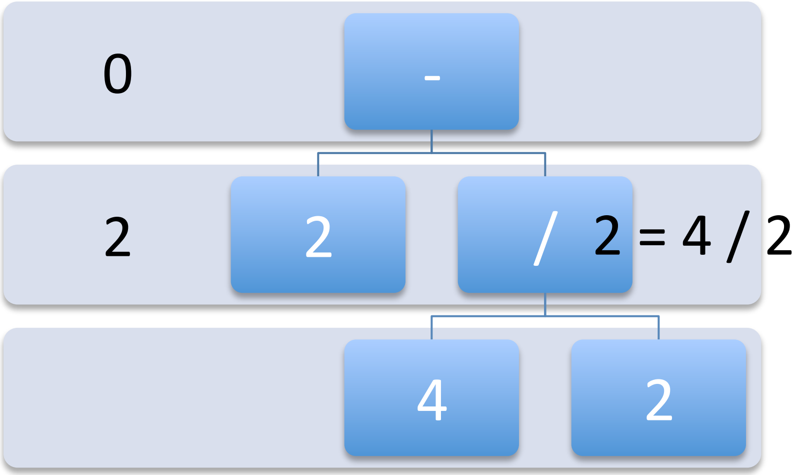
4

1 = 2 / 2

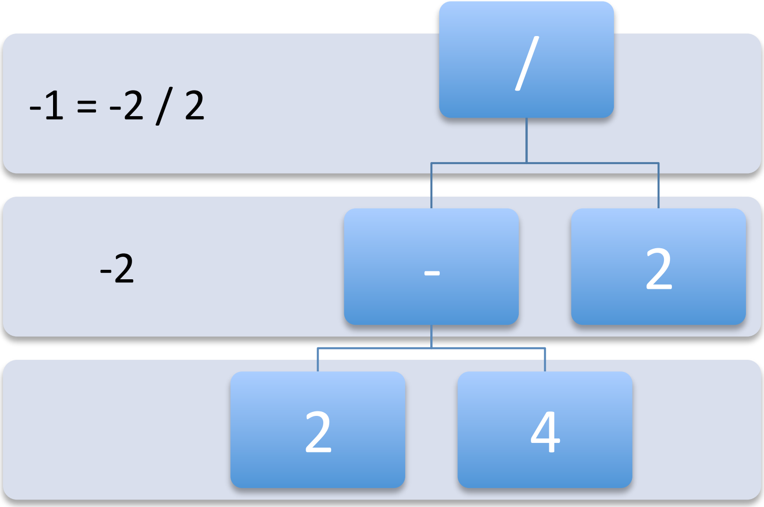
Ambigüedad: Prioridad

```
e  : e ‘–‘ e {  $$ = $1 - $3; }
   | e ‘/‘ e {  $$ = $1 / $3; }
   | NUM  { $$ = Number($1);  }
   ;
```

2-(4/2)



(2-4)/2



Ambigüedad: Prioridad
2-4/2

2.-4/2 <= e.-4/2<=e-.4/2<=e-4./2<=e-e./2

¿Qué hacer?

1. <= e./2 <= e/. 2 <= e/e.<= e.
2. <= e-e/.2 <= e–e/2.<= e–e/e.<= e–e. <= e.

El conflicto es entre la regla e -> e '-' e y el terminal '/'

Ambigüedad: Prioridad

Mas prioridad

```
%left ‘-’
%left ‘/’
%%
e  : e ‘– ‘ e { $$ = $1 - $3; }
   | e ‘/ ‘ e { $$ = $1 / $3; }
   | NUM  { $$ = Number($1);  }
   ;
```

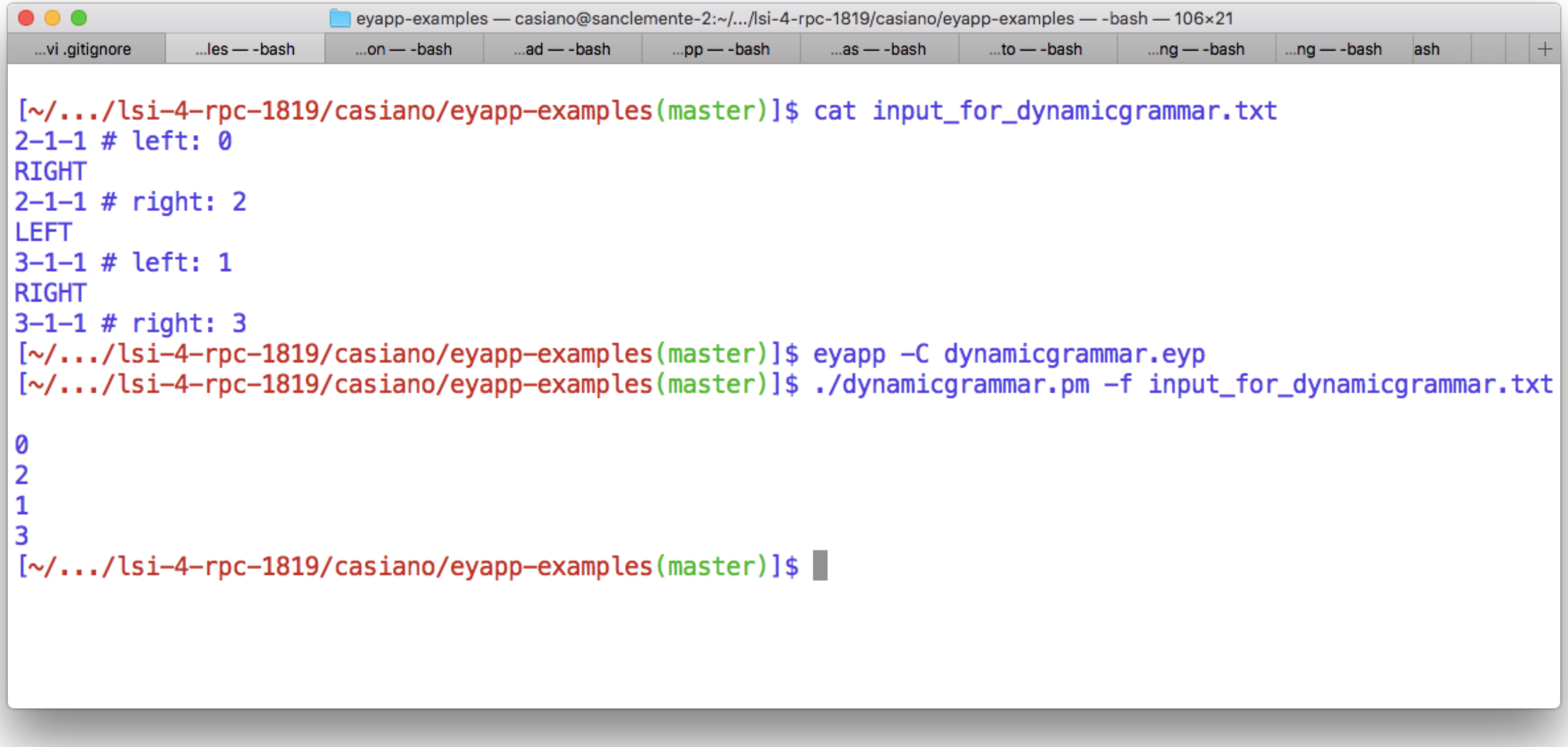
En la lucha entre reducir por la regla e -> e ‘-’ e y desplazar el terminal ‘/’ debe “ganar” el token

Dynamic Resolution of Shift-Reduce Conflicts

Write a language that accepts lists of two kind of commands: *arithmetic expressions* like *4-2-1* or one of two *commands*: *left* or *right*.

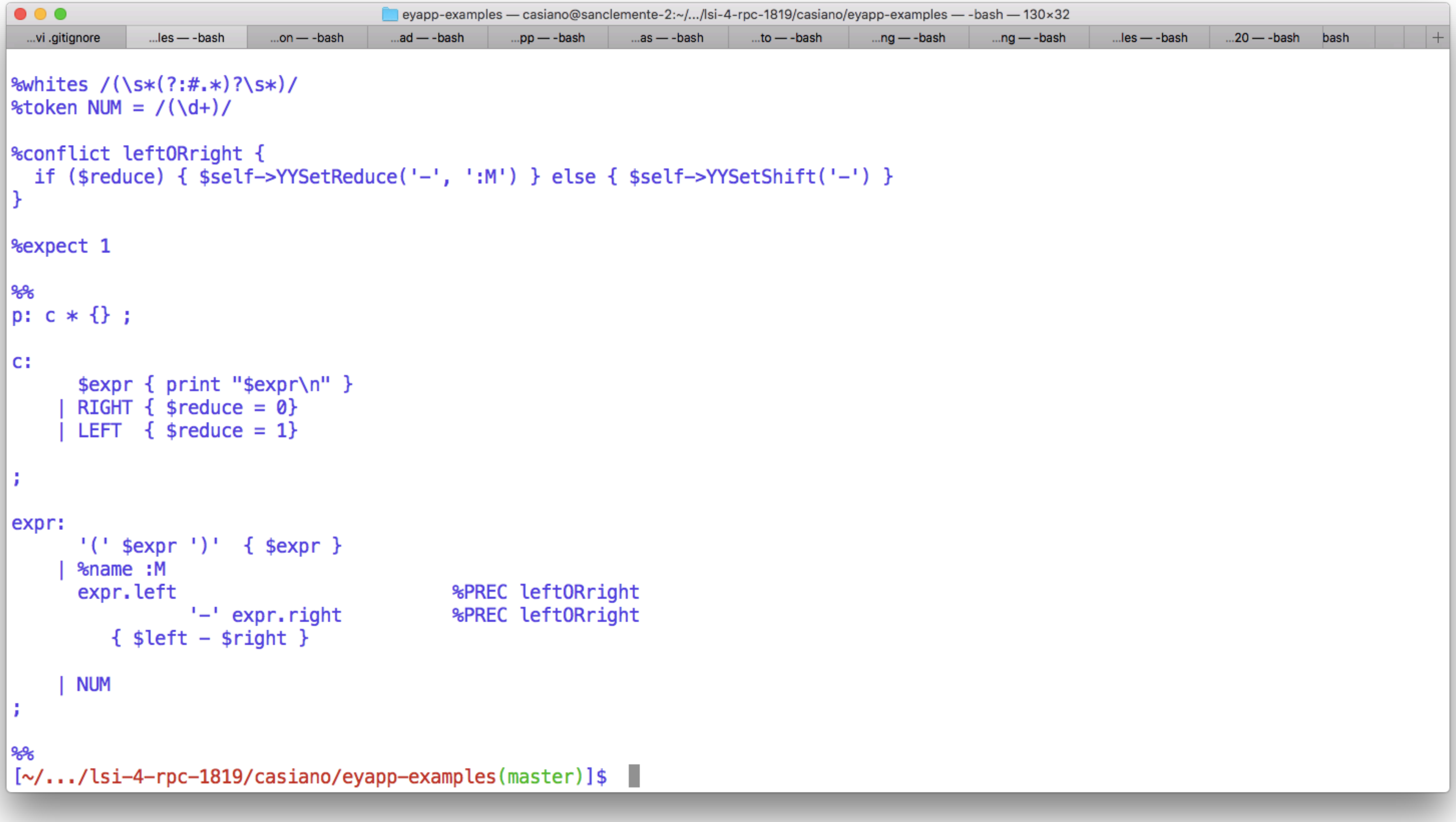
- When a *right* command is issued, the semantic of the *'-'* operator is changed to be right associative.
- When a *left* command is issued the semantic for *'-'* returns to left associative interpretation.

Dynamic Resolution of Shift-Reduce Conflicts



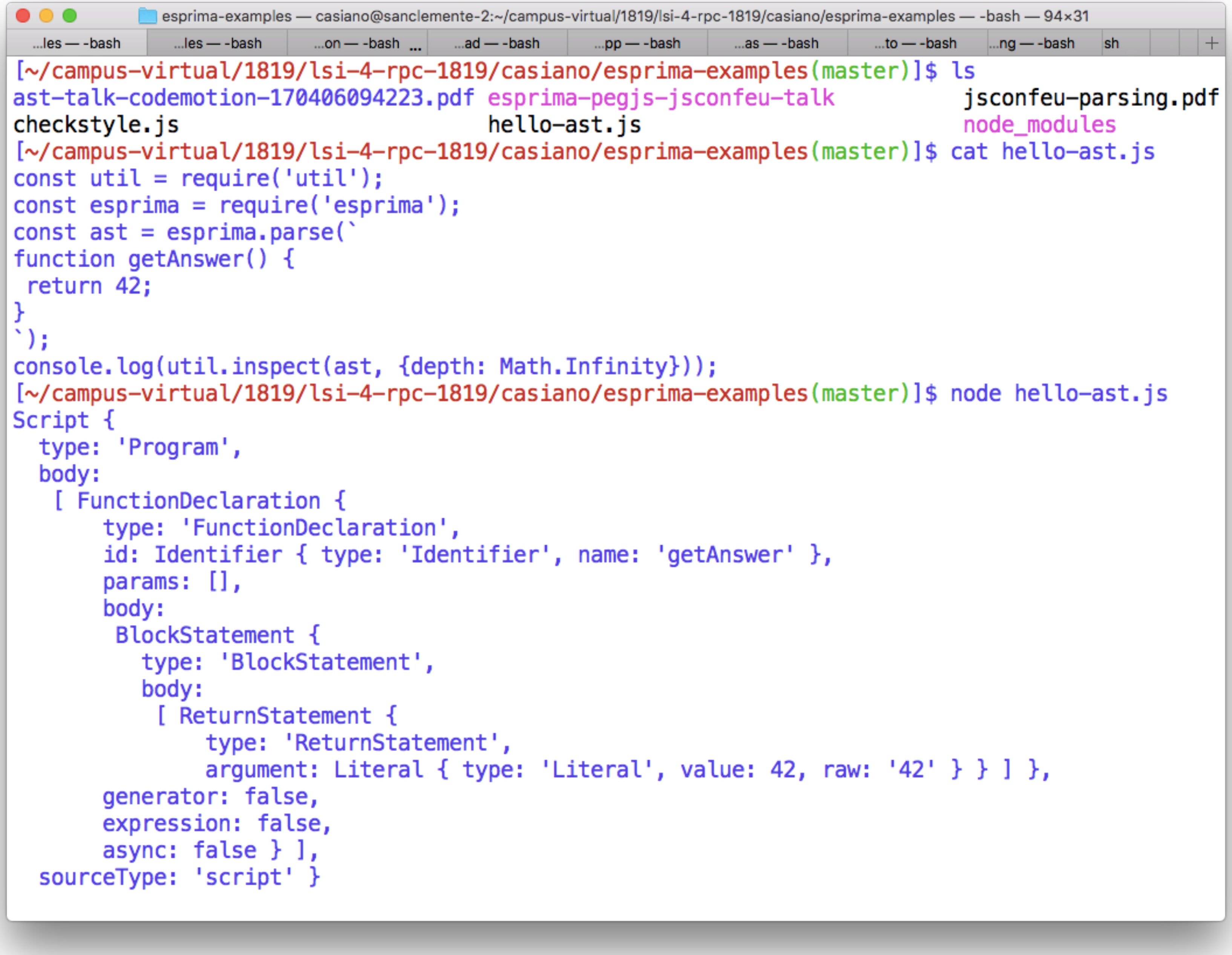
```
[~/.../lsi-4-rpc-1819/casiano/eyapp-examples(master)]$ cat input_for_dynamicgrammar.txt
2-1-1 # left: 0
RIGHT
2-1-1 # right: 2
LEFT
3-1-1 # left: 1
RIGHT
3-1-1 # right: 3
[~/.../lsi-4-rpc-1819/casiano/eyapp-examples(master)]$ eyapp -C dynamicgrammar.eyp
[~/.../lsi-4-rpc-1819/casiano/eyapp-examples(master)]$ ./dynamicgrammar.pm -f input_for_dynamicgrammar.txt

0
2
1
3
[~/.../lsi-4-rpc-1819/casiano/eyapp-examples(master)]$ 
```

Dynamic Resolution of Shift-Reduce Conflicts



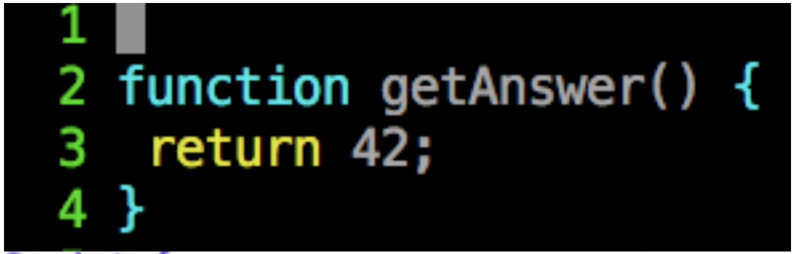
```
%whites /(\s*(?:#.*)?\s*)/
%token NUM = /(\d+)/

%conflict leftORright {
  if ($reduce) { $self->YYSetReduce('-', ':M') } else { $self->YYSetShift('-') }
}

%expect 1

%%
p: c * {} ;

c:
      $expr { print "$expr\n" }
    | RIGHT { $reduce = 0}
    | LEFT  { $reduce = 1}

;

expr:
      '(' $expr ')'  { $expr }
    | %name :M
      expr.left                         %PREC leftORright
                '-' expr.right          %PREC leftORright
         { $left - $right }

    | NUM
;

%%
[~/.../lsi-4-rpc-1819/casiano/eyapp-examples(master)]$ 
```

Parsing, Traversing and Code Generation

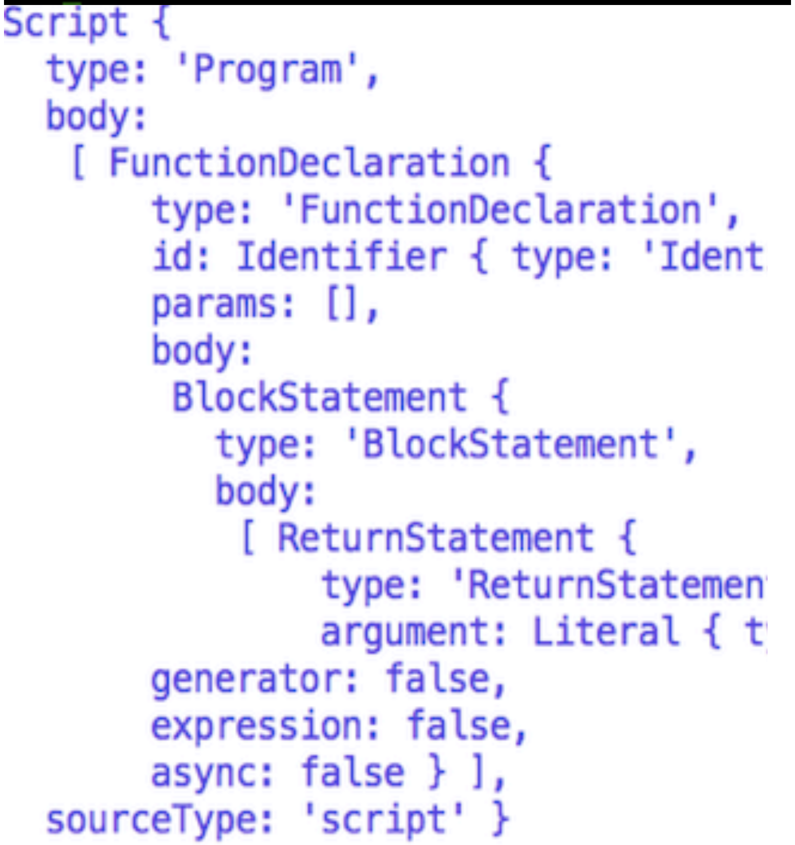

esprima-examples — casiano@sanclemente-2:~/campus-virtual/1819/lsi-4-rpc-1819/casiano/esprima-examples — -bash — 94×31
...les — -bash
...les — -bash
...on — -bash
...ad — -bash
...pp — -bash
...as — -bash
...to — -bash
...ng — -bash
sh

```
[~/campus-virtual/1819/lsi-4-rpc-1819/casiano/esprima-examples(master)]$ ls
ast-talk-codemotion-170406094223.pdf esprima-pegjs-jsconfeu-talk          jsconfeu-parsing.pdf
checkstyle.js                        hello-ast.js                         node_modules
[~/campus-virtual/1819/lsi-4-rpc-1819/casiano/esprima-examples(master)]$ cat hello-ast.js
const util = require('util');
const esprima = require('esprima');
const ast = esprima.parse(`
function getAnswer() {
 return 42;
}
`);
console.log(util.inspect(ast, {depth: Math.Infinity}));
[~/campus-virtual/1819/lsi-4-rpc-1819/casiano/esprima-examples(master)]$ node hello-ast.js
Script {
  type: 'Program',
  body:
   [ FunctionDeclaration {
       type: 'FunctionDeclaration',
       id: Identifier { type: 'Identifier', name: 'getAnswer' },
       params: [],
       body:
        BlockStatement {
          type: 'BlockStatement',
          body:
           [ ReturnStatement {
               type: 'ReturnStatement',
               argument: Literal { type: 'Literal', value: 42, raw: '42' } } ] },
       generator: false,
       expression: false,
       async: false } ],
  sourceType: 'script' }
```

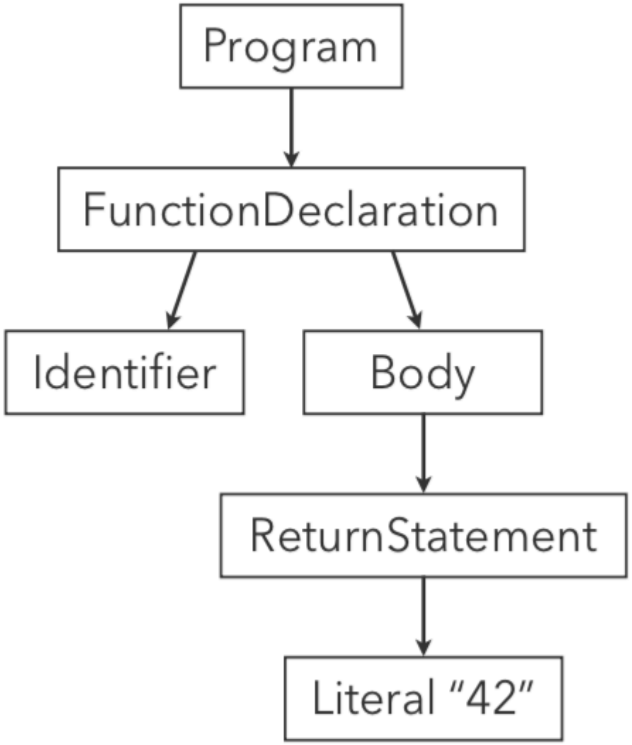
Parsing, Traversing and Code Generation



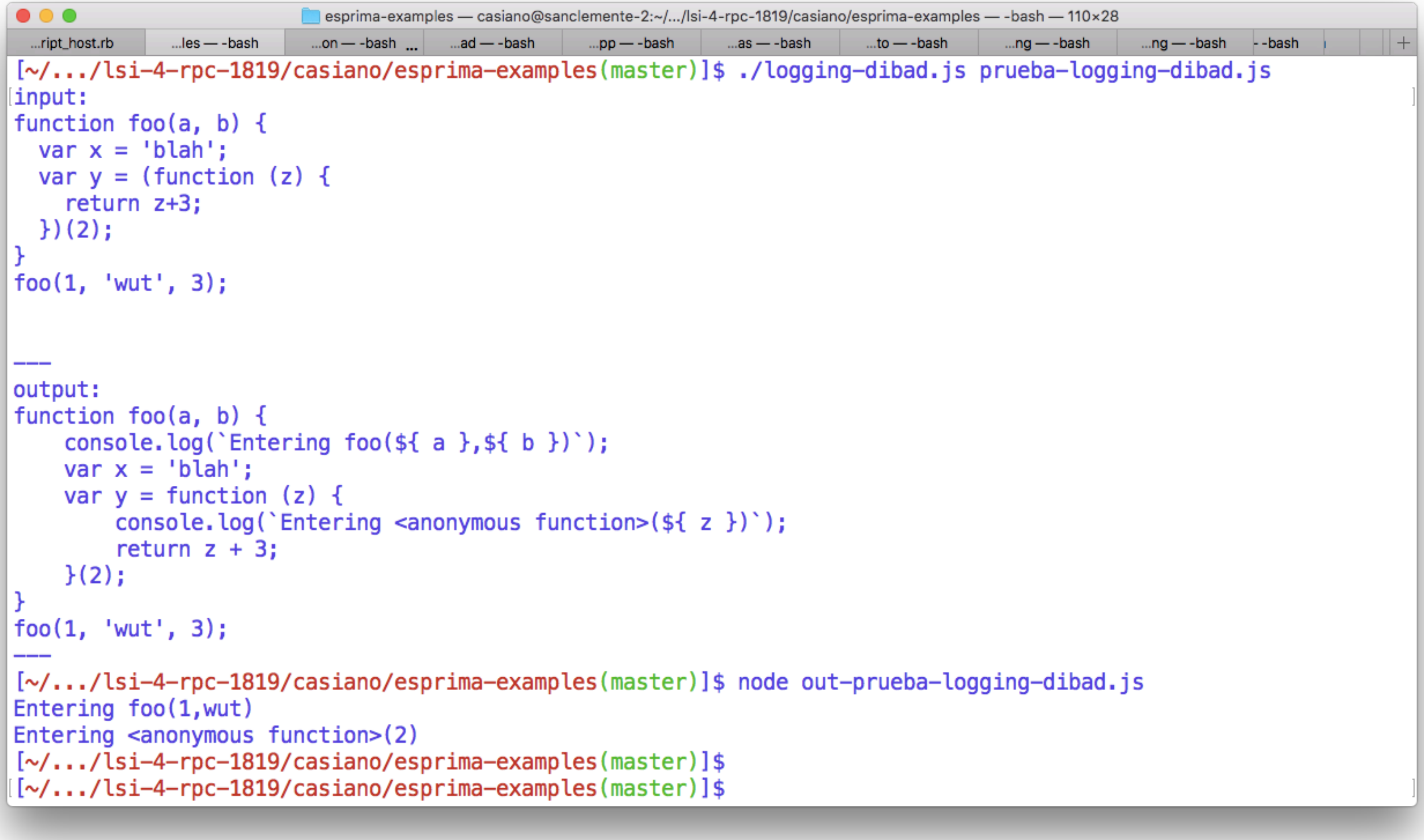
```

function getAnswer() {
 return 42;
}
```



```
Script {
  type: 'Program',
  body:
   [ FunctionDeclaration {
       type: 'FunctionDeclaration',
       id: Identifier { type: 'Ident
       params: [],
       body:
        BlockStatement {
          type: 'BlockStatement',
          body:
           [ ReturnStatement {
               type: 'ReturnStatemen
               argument: Literal { t
       generator: false,
       expression: false,
       async: false } ],
  sourceType: 'script' }
```

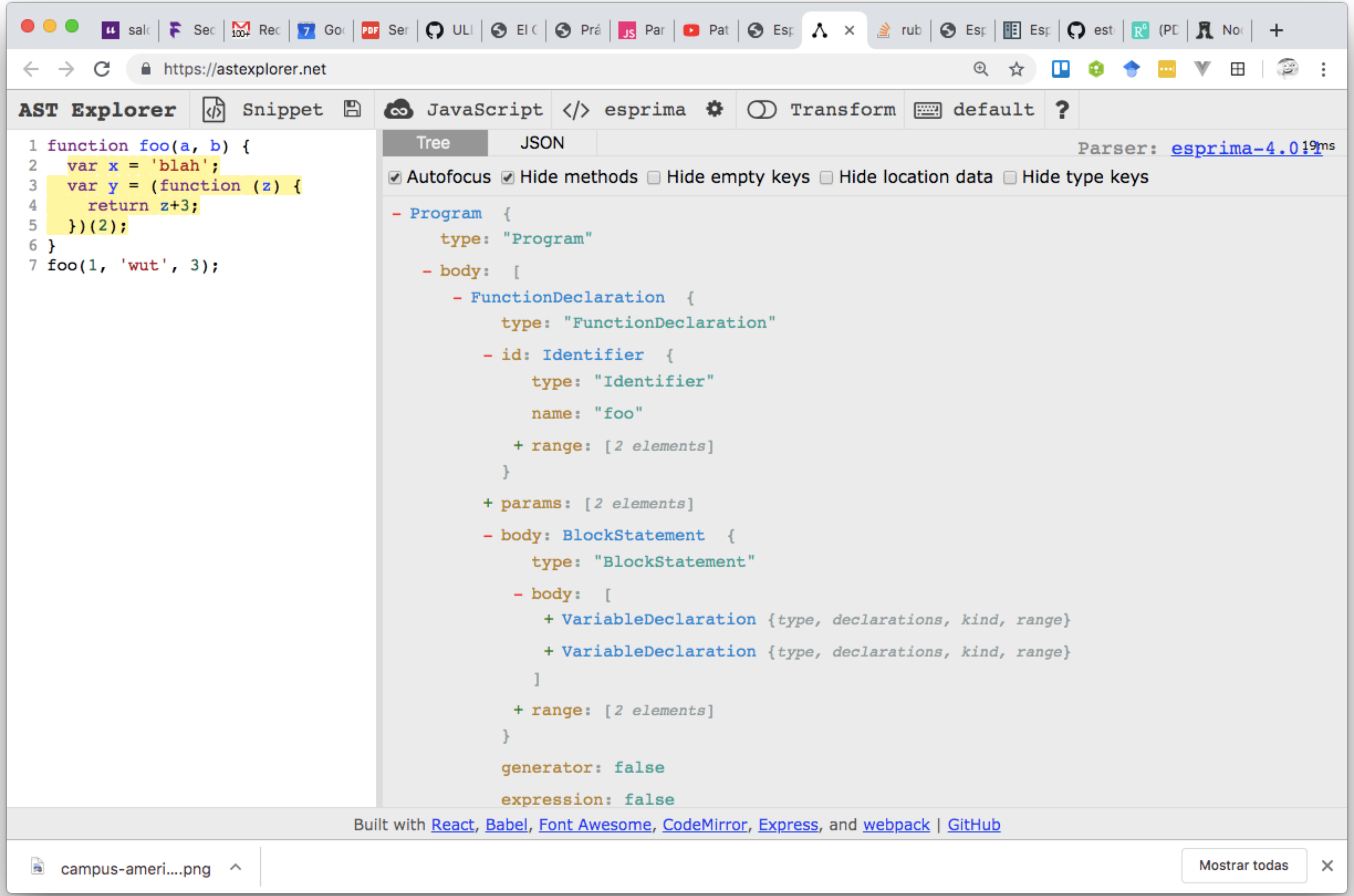


Parsing and Traversing Example: Logging function calls



```
[~/.../lsi-4-rpc-1819/casiano/esprima-examples(master)]$ ./logging-dibad.js prueba-logging-dibad.js
input:
function foo(a, b) {
  var x = 'blah';
  var y = (function (z) {
    return z+3;
  })(2);
}
foo(1, 'wut', 3);



---
output:
function foo(a, b) {
    console.log(`Entering foo(${ a },${ b })`);
    var x = 'blah';
    var y = function (z) {
        console.log(`Entering <anonymous function>(${ z })`);
        return z + 3;
    }(2);
}
foo(1, 'wut', 3);
---
[~/.../lsi-4-rpc-1819/casiano/esprima-examples(master)]$ node out-prueba-logging-dibad.js
Entering foo(1,wut)
Entering <anonymous function>(2)
[~/.../lsi-4-rpc-1819/casiano/esprima-examples(master)]$
[~/.../lsi-4-rpc-1819/casiano/esprima-examples(master)]$
```

https://astexplorer.net/

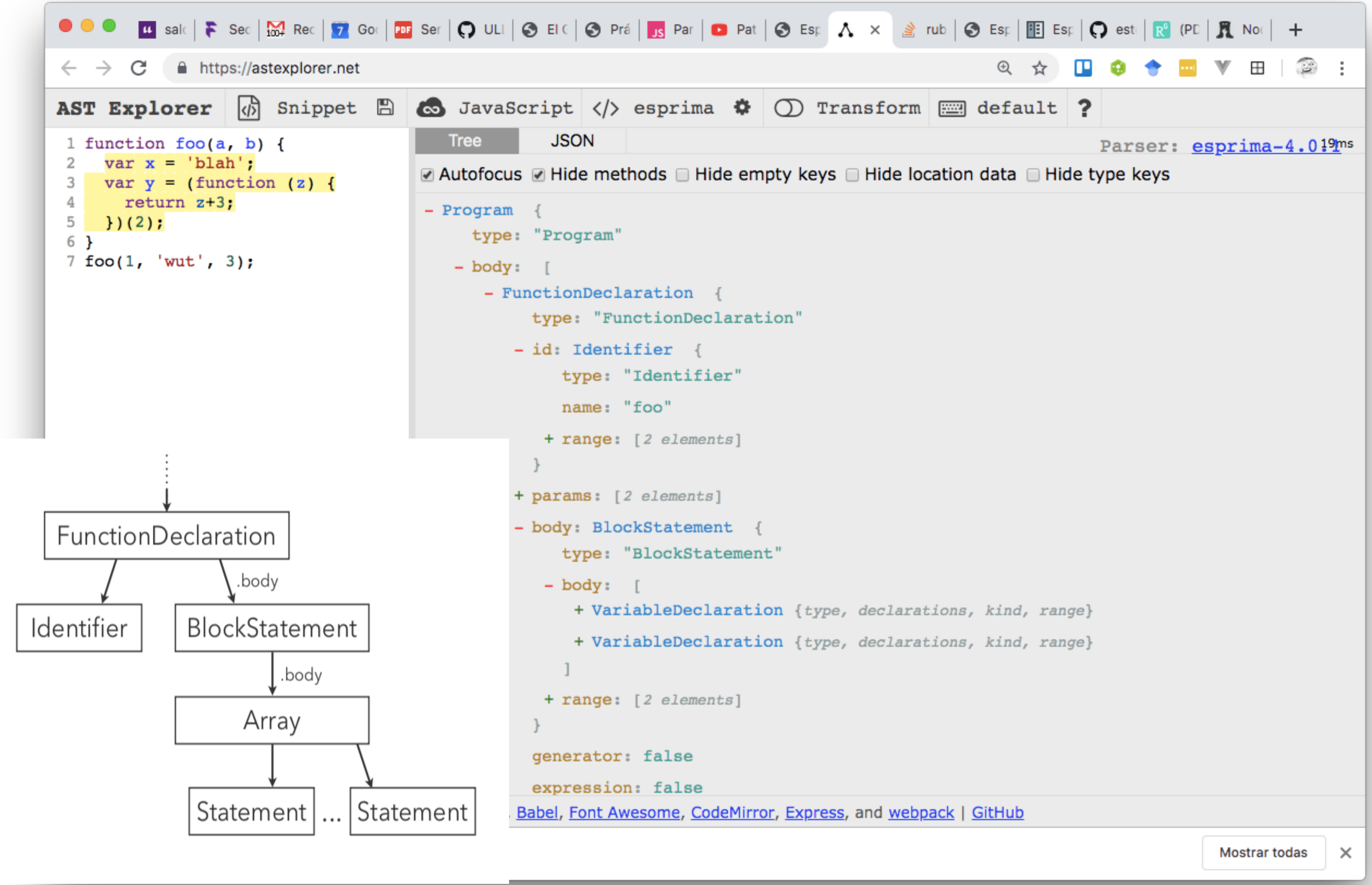


```
function foo(a, b) {
  var x = 'blah';
  var y = (function (z) {
    return z+3;
  })(2);
}
foo(1, 'wut', 3);
```

```
- Program  {
     type: "Program"
   - body:  [
      - FunctionDeclaration  {
           type: "FunctionDeclaration"
         - id: Identifier  {
              type: "Identifier"
              name: "foo"
            + range: [2 elements]
           }
         + params: [2 elements]
         - body: BlockStatement  {
              type: "BlockStatement"
            - body:  [
               + VariableDeclaration {type, declarations, kind, range}
               + VariableDeclaration {type, declarations, kind, range}
              ]
            + range: [2 elements]
           }
           generator: false
           expression: false
```

Built with React, Babel, Font Awesome, CodeMirror, Express, and webpack | GitHub

https://astexplorer.net/

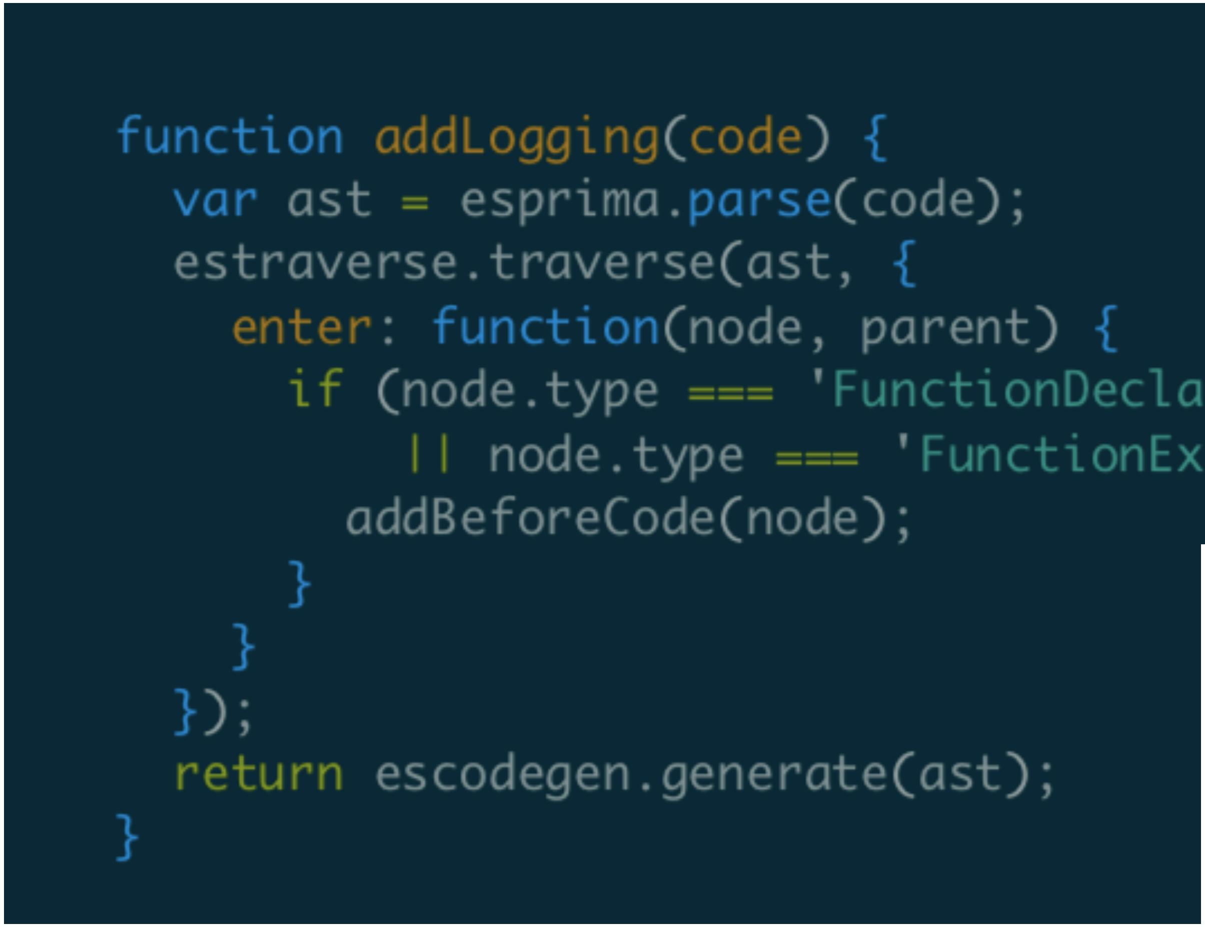


```
function foo(a, b) {
  var x = 'blah';
  var y = (function (z) {
    return z+3;
  })(2);
}
foo(1, 'wut', 3);
```

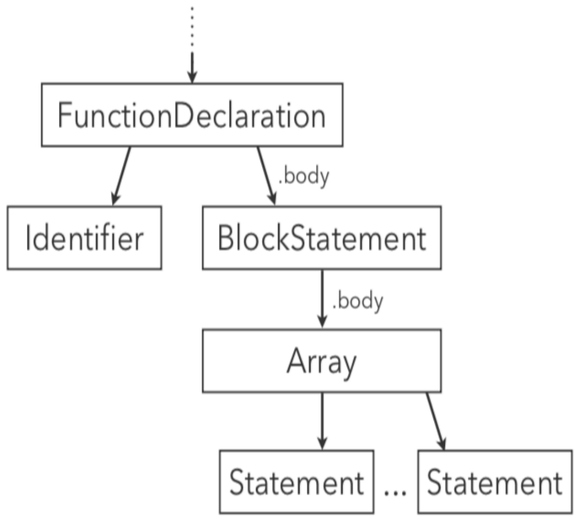
☑ Autofocus ☑ Hide methods □ Hide empty keys □ Hide location data □ Hide type keys

```
- Program  {
    type: "Program"
  - body:  [
    - FunctionDeclaration  {
        type: "FunctionDeclaration"
      - id: Identifier  {
          type: "Identifier"
          name: "foo"
        + range: [2 elements]
        }
      + params: [2 elements]
      - body: BlockStatement  {
          type: "BlockStatement"
        - body:  [
          + VariableDeclaration {type, declarations, kind, range}
          + VariableDeclaration {type, declarations, kind, range}
          ]
        + range: [2 elements]
        }
        generator: false
        expression: false
```

Parsing, Traversing and Generating Code

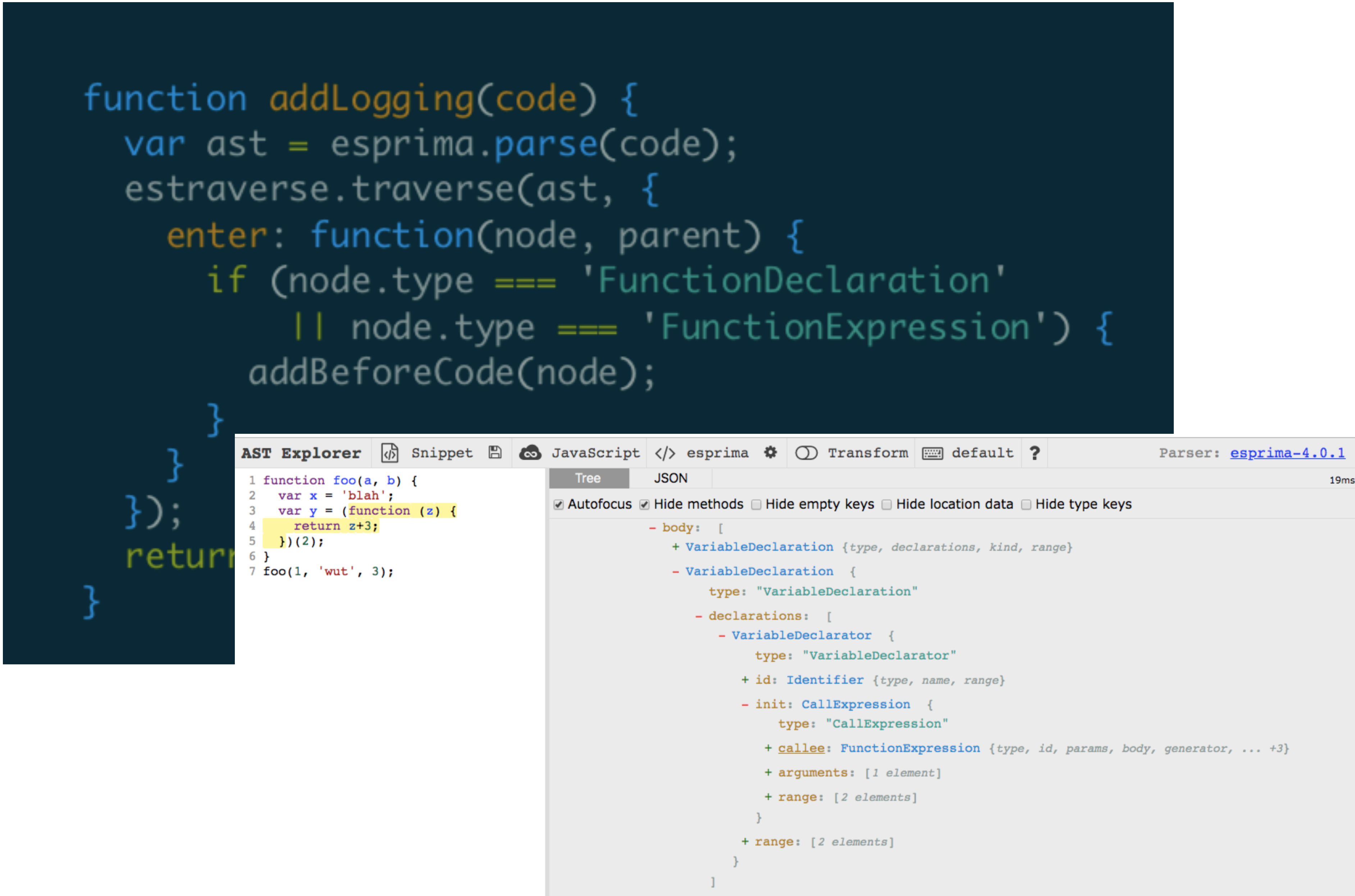


```
function addLogging(code) {
  var ast = esprima.parse(code);
  estraverse.traverse(ast, {
    enter: function(node, parent) {
      if (node.type === 'FunctionDeclaration'
          || node.type === 'FunctionExpression') {
        addBeforeCode(node);
      }
    }
  });
  return escodegen.generate(ast);
}
```



API de estraverse: https://github.com/estools/estraverse

Parsing, Traversing and Generating Code



```
function addLogging(code) {
  var ast = esprima.parse(code);
  estraverse.traverse(ast, {
    enter: function(node, parent) {
      if (node.type === 'FunctionDeclaration'
          || node.type === 'FunctionExpression') {
        addBeforeCode(node);
      }
    }
  });
  retur
}
```

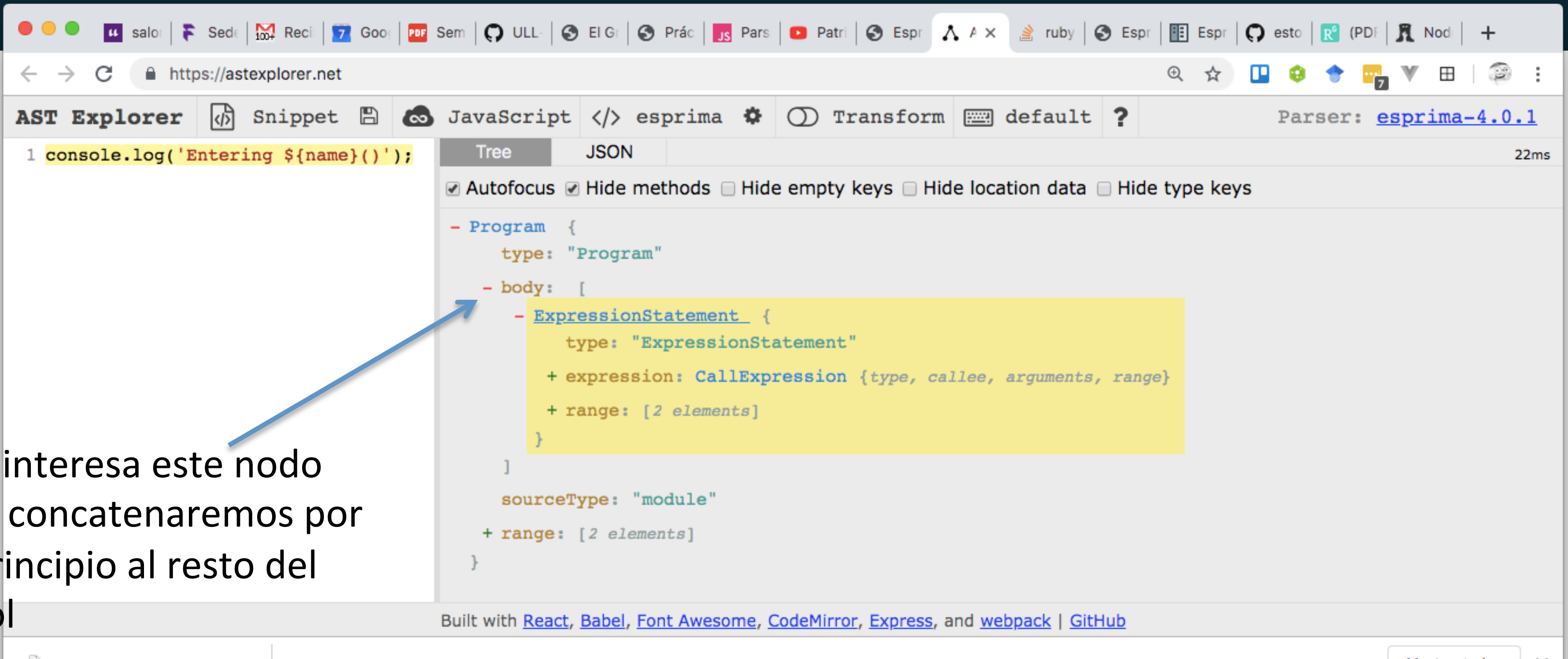
```
function foo(a, b) {
  var x = 'blah';
  var y = (function (z) {
    return z+3;
  })(2);
}
foo(1, 'wut', 3);
```

☑ Autofocus ☑ Hide methods □ Hide empty keys □ Hide location data □ Hide type keys

```
- body: [
   + VariableDeclaration {type, declarations, kind, range}
   - VariableDeclaration {
        type: "VariableDeclaration"
      - declarations: [
         - VariableDeclarator {
              type: "VariableDeclarator"
            + id: Identifier {type, name, range}
            - init: CallExpression {
                 type: "CallExpression"
               + callee: FunctionExpression {type, id, params, body, generator, ... +3}
               + arguments: [1 element]
               + range: [2 elements]
              }
            + range: [2 elements]
           }
        ]
```

Traversing and Modifying the AST

```
function addBeforeCode(node) {
  var name = node.id ? node.id.name : '<anonymous function>';
  var beforeCode = "console.log('Entering " + name + "()');";
  var beforeNodes = esprima.parse(beforeCode).body;
  node.body.body = beforeNodes.concat(node.body.body);
}
```



```
console.log('Entering ${name}()');
```

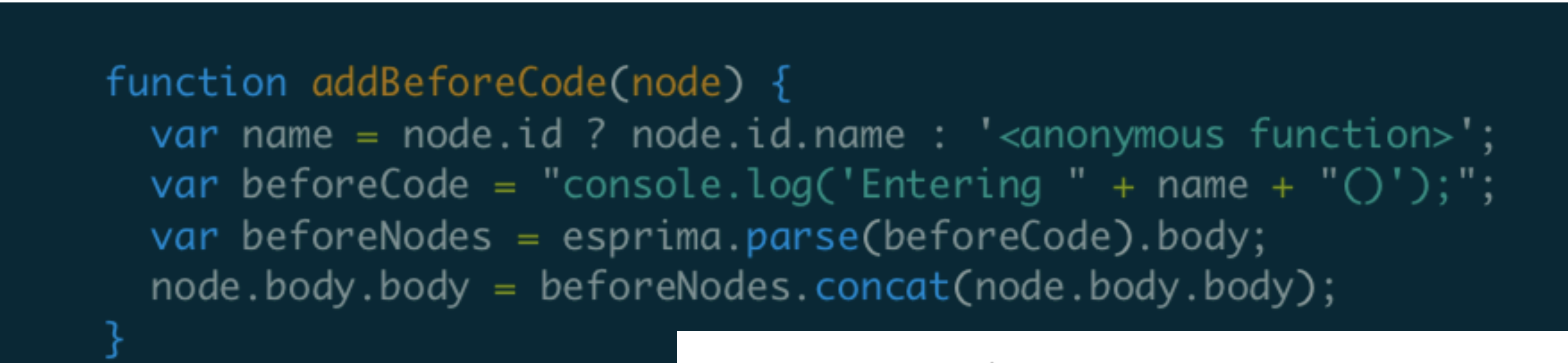
☑ Autofocus ☑ Hide methods □ Hide empty keys □ Hide location data □ Hide type keys

```
- Program {
    type: "Program"
  - body: [
    - ExpressionStatement {
        type: "ExpressionStatement"
      + expression: CallExpression {type, callee, arguments, range}
      + range: [2 elements]
      }
    ]
    sourceType: "module"
  + range: [2 elements]
  }
```

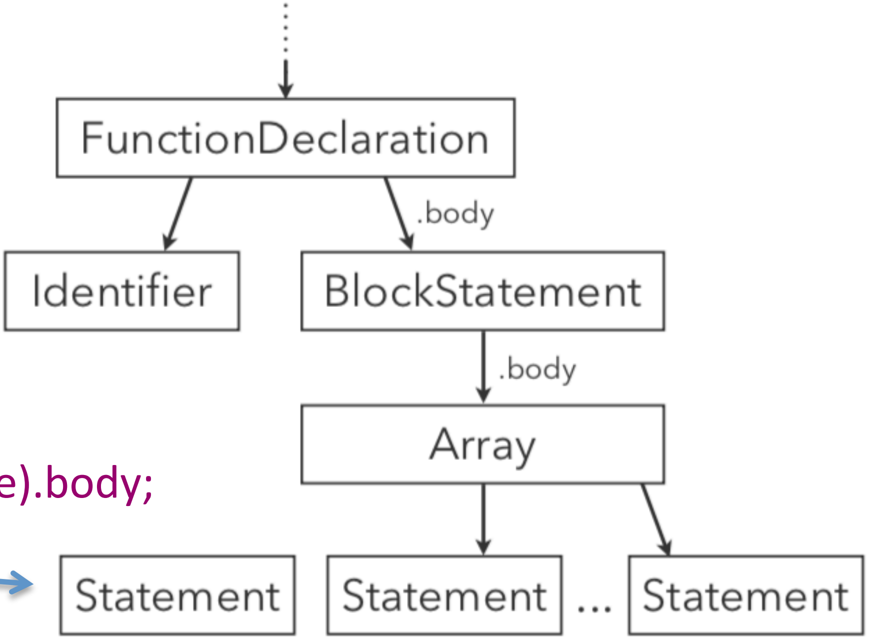
Built with React, Babel, Font Awesome, CodeMirror, Express, and webpack | GitHub

Nos interesa este nodo
Que concatenaremos por
el principio al resto del
árbol

Traversing and Modifying the AST

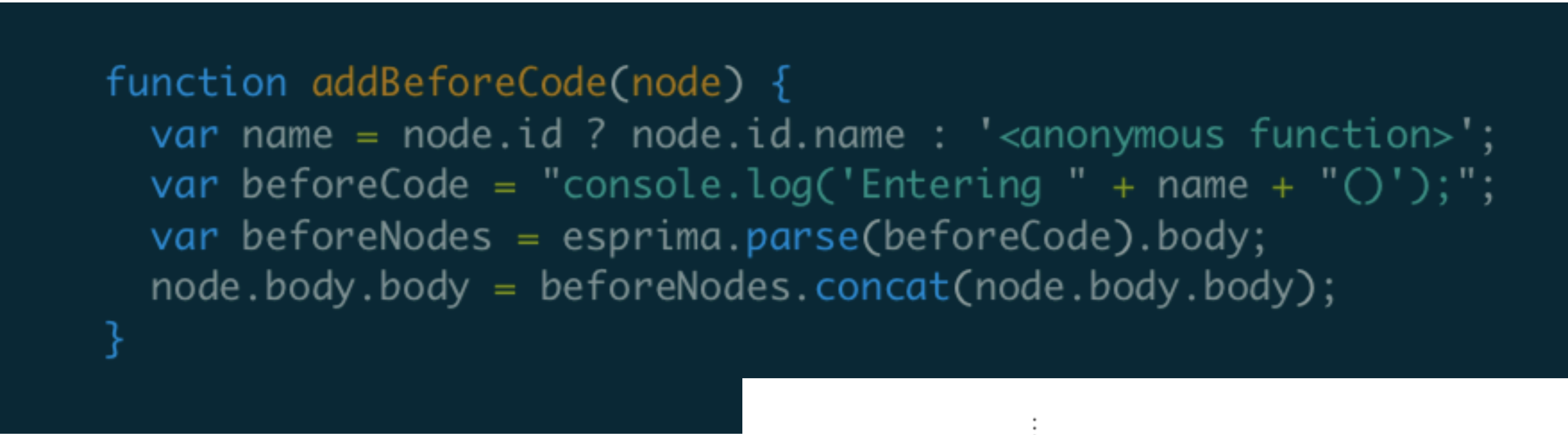


```
function addBeforeCode(node) {
  var name = node.id ? node.id.name : '<anonymous function>';
  var beforeCode = "console.log('Entering " + name + "()');";
  var beforeNodes = esprima.parse(beforeCode).body;
  node.body.body = beforeNodes.concat(node.body.body);
}
```

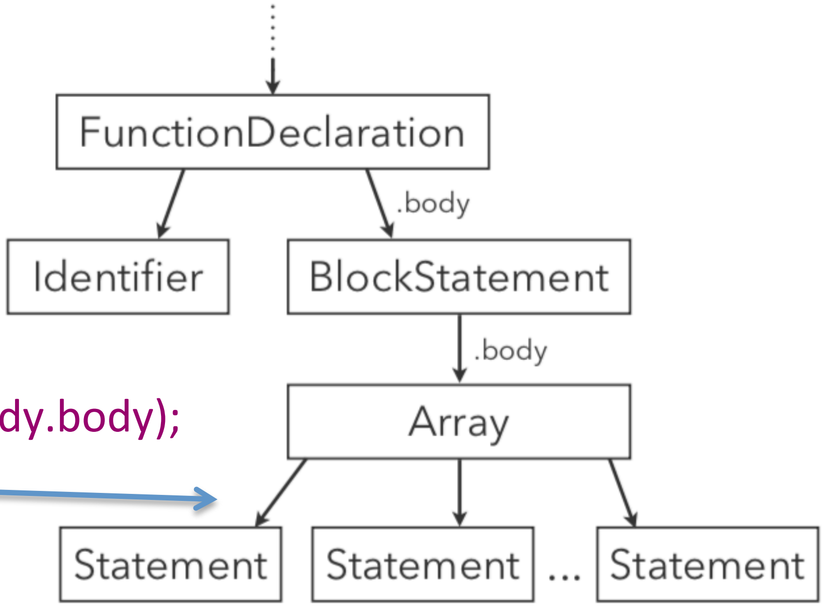


var beforeNodes = esprima.parse(beforeCode).body;

Parsing, Traversing and Modifying the AST



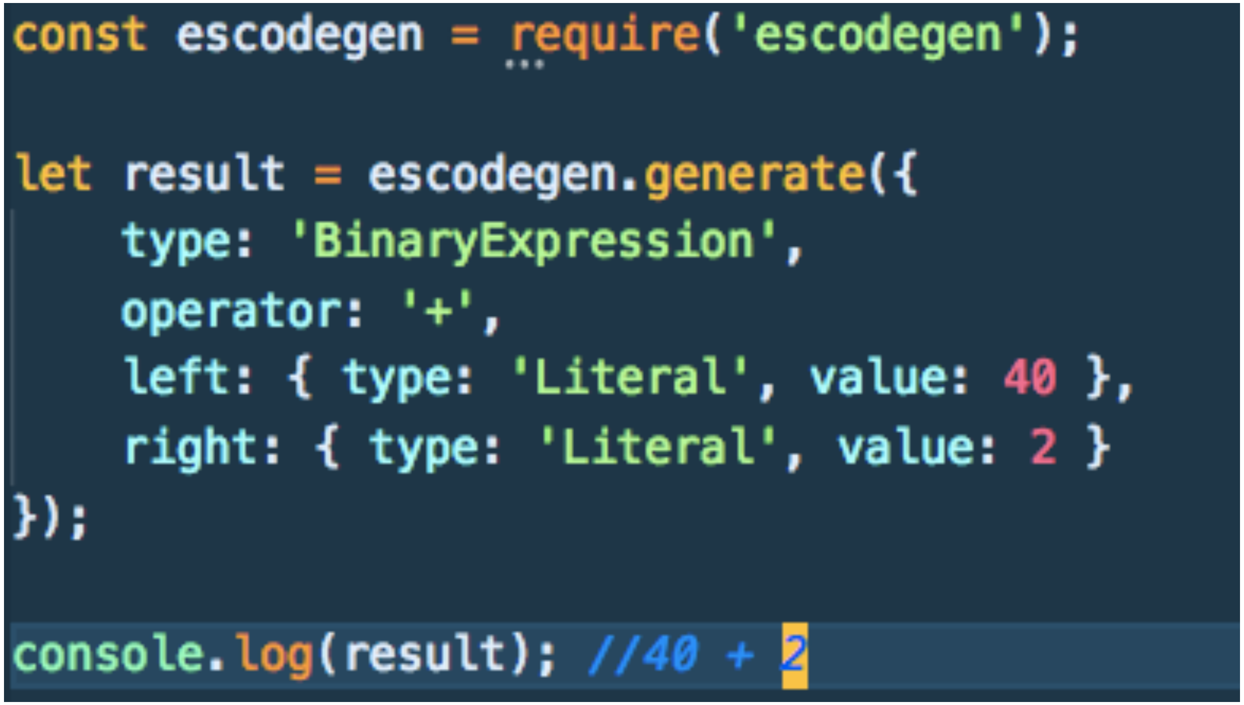
```
function addBeforeCode(node) {
  var name = node.id ? node.id.name : '<anonymous function>';
  var beforeCode = "console.log('Entering " + name + "()');";
  var beforeNodes = esprima.parse(beforeCode).body;
  node.body.body = beforeNodes.concat(node.body.body);
}
```



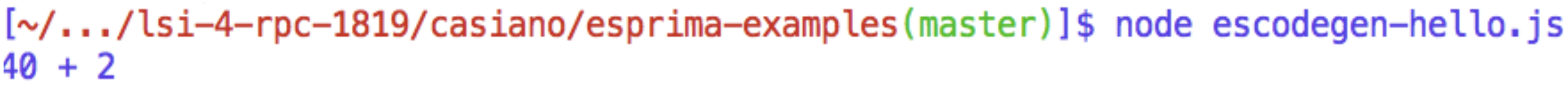
node.body.body = beforeNodes.concat(node.body.body);

El método concat() se usa para unir dos o más arrays

Generating Code from the AST



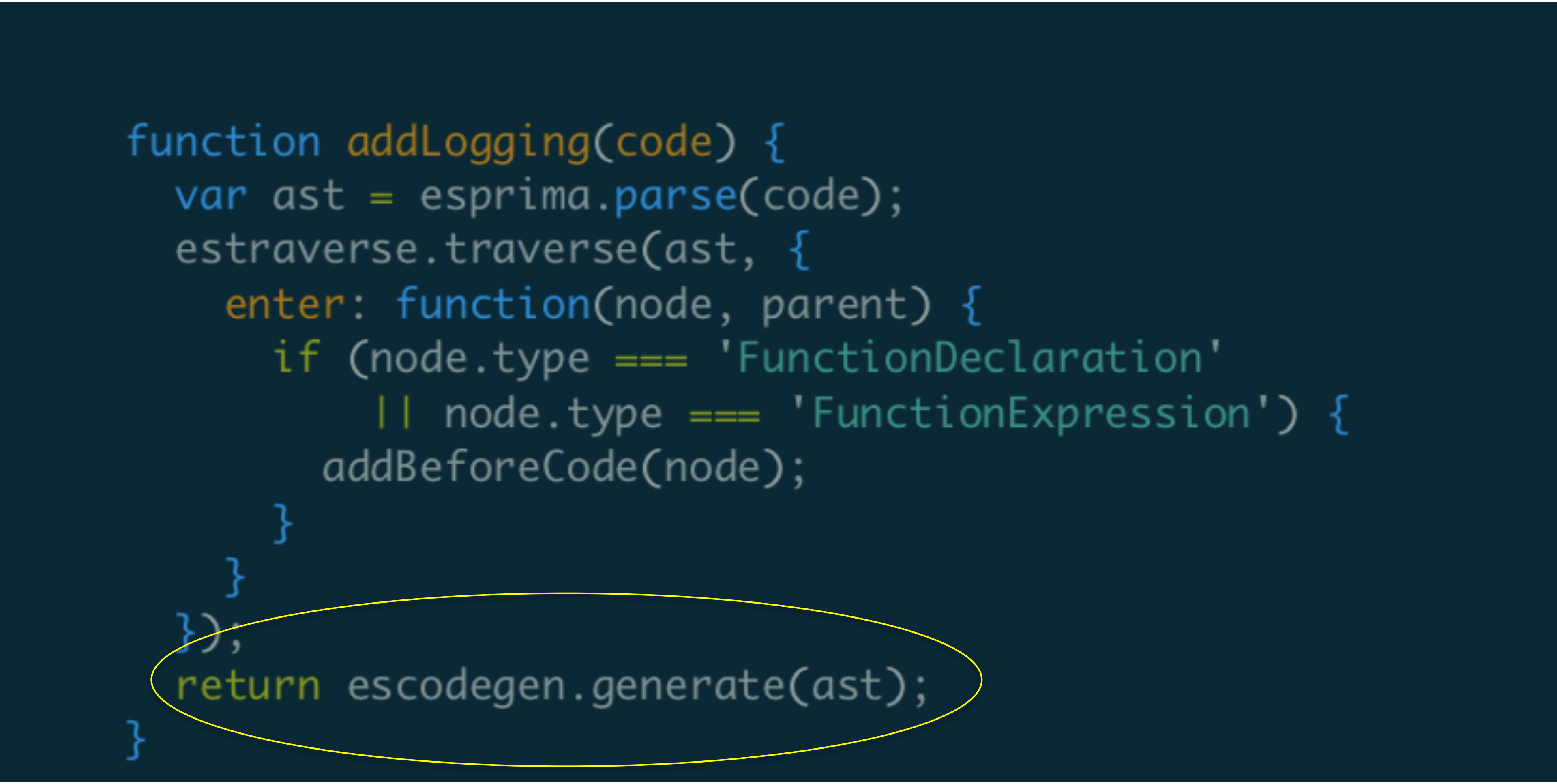
```
const escodegen = require('escodegen');

let result = escodegen.generate({
    type: 'BinaryExpression',
    operator: '+',
    left: { type: 'Literal', value: 40 },
    right: { type: 'Literal', value: 2 }
});

console.log(result); //40 + 2
```



```
[~/.../lsi-4-rpc-1819/casiano/esprima-examples(master)]$ node escodegen-hello.js
40 + 2
```

API de escodegen: https://github.com/estools/escodegen/wiki/API

Generating Code from the AST



```
function addLogging(code) {
  var ast = esprima.parse(code);
  estraverse.traverse(ast, {
    enter: function(node, parent) {
      if (node.type === 'FunctionDeclaration'
          || node.type === 'FunctionExpression') {
        addBeforeCode(node);
      }
    }
  });
  return escodegen.generate(ast);
}
```

Recursos

- Repositorio GitHub con los recursos de la charla: https://github.com/ULL-LSI/campus-america-2019
- Apuntes de Procesadores de Lenguajes. Curso 2018/2019: https://ull-esit-pl-1819.github.io/introduccion/
- Rodriguez-Leon, Casiano & Garcia-Forte, L. (2011). Solving Difficult LR Parsing Conflicts by Postponing Them. Comput. Sci. Inf. Syst.. 8. 517-531. 10.2298/CSIS101116008R.
- Parse Eyapp en CPAN
- Parsing Strings and Trees with Parse::Eyapp (An Introduction to Compiler Construction). 2010
- Patrick Dubroy: Parsing, Compiling, and Static Metaprogramming
- https://astexplorer.net/