61A Lecture 27

November 2, 2011

Parsing

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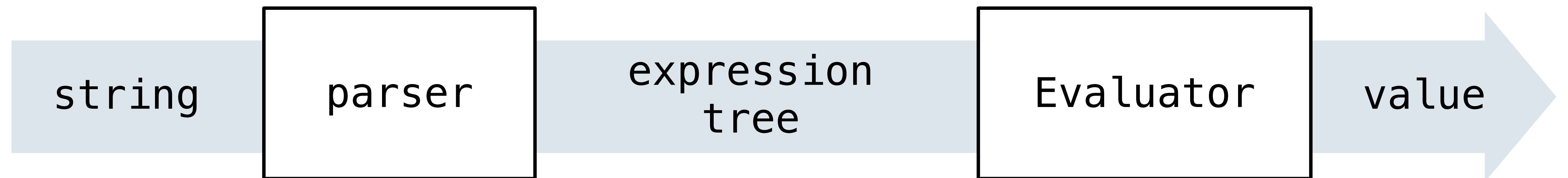

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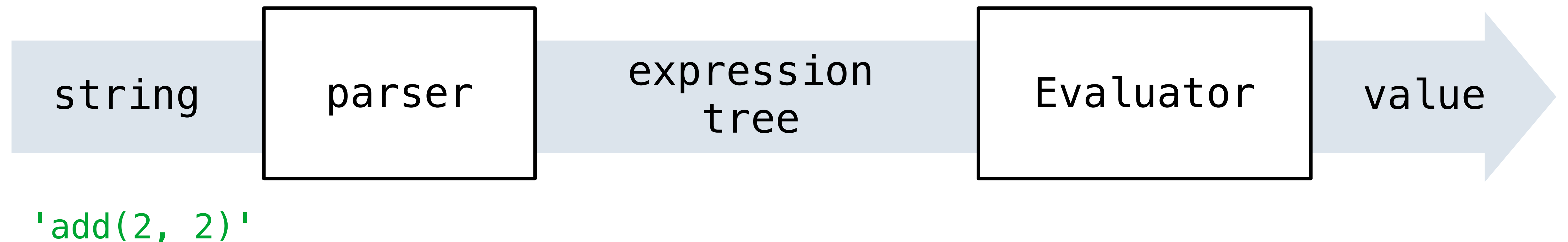

'add(2, 2)'

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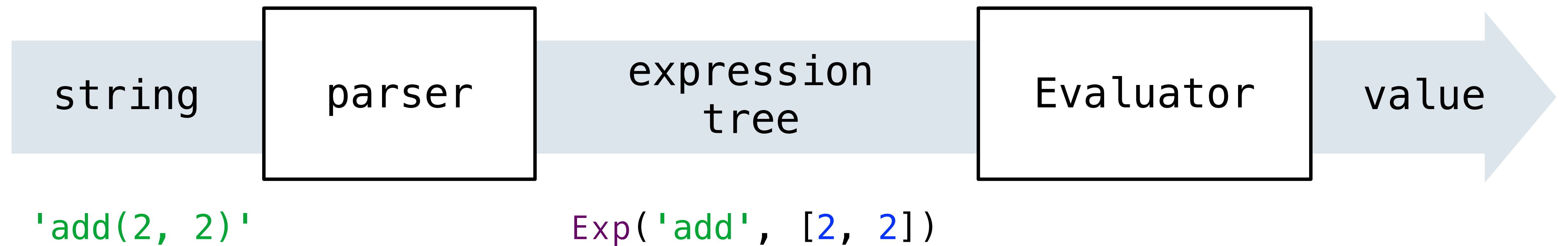

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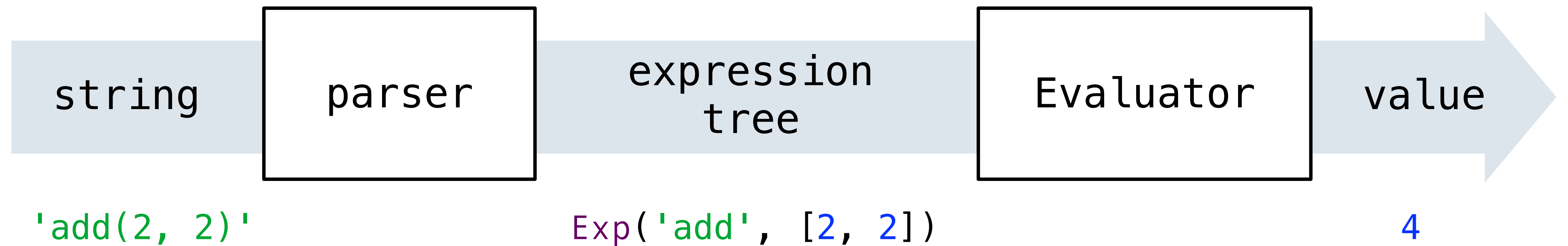

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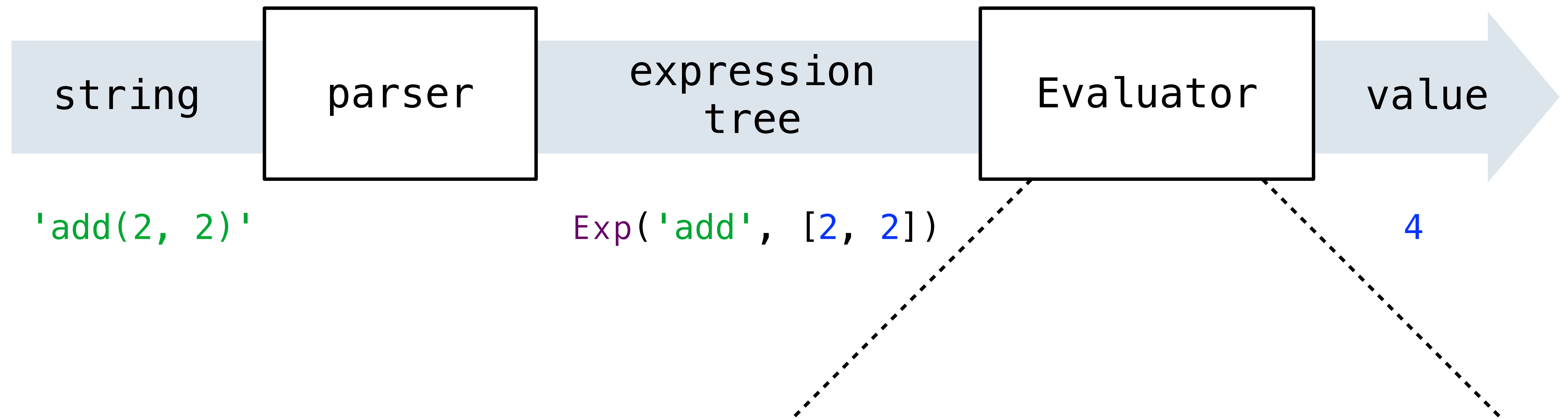

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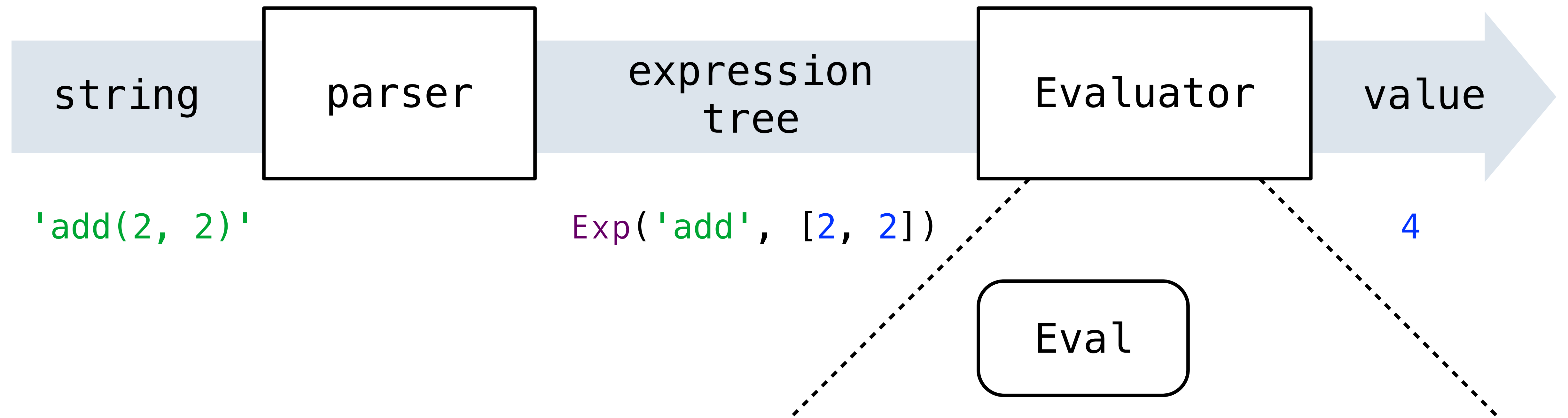

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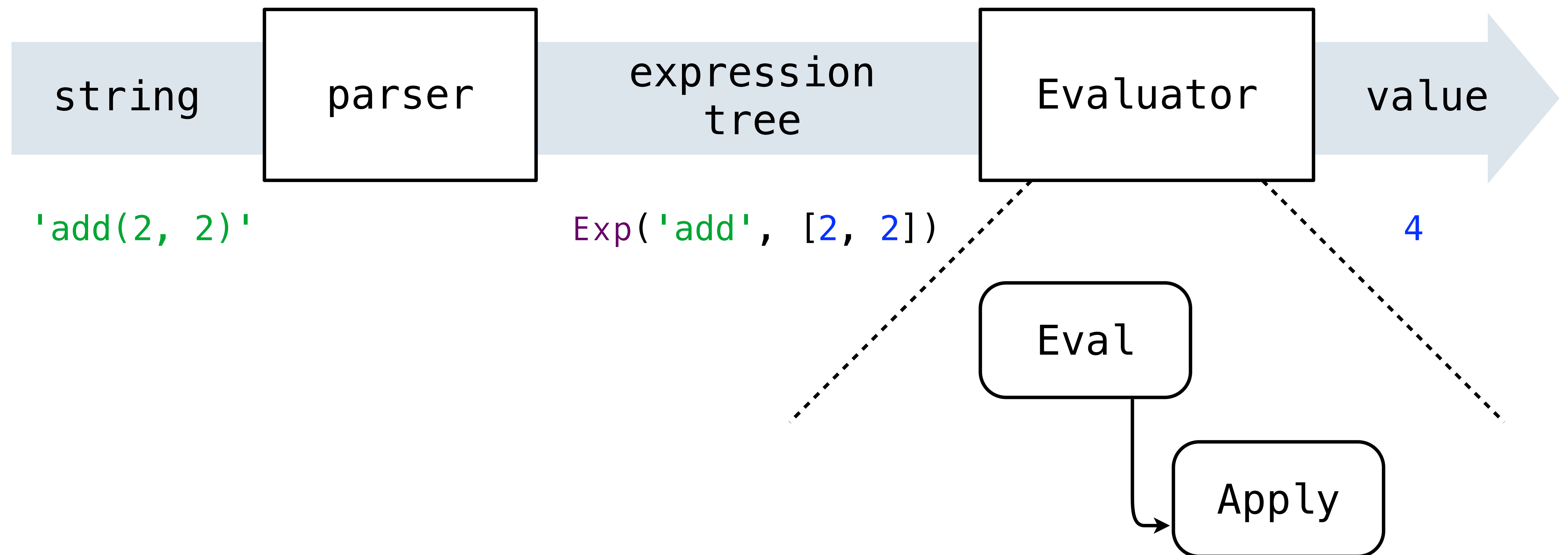

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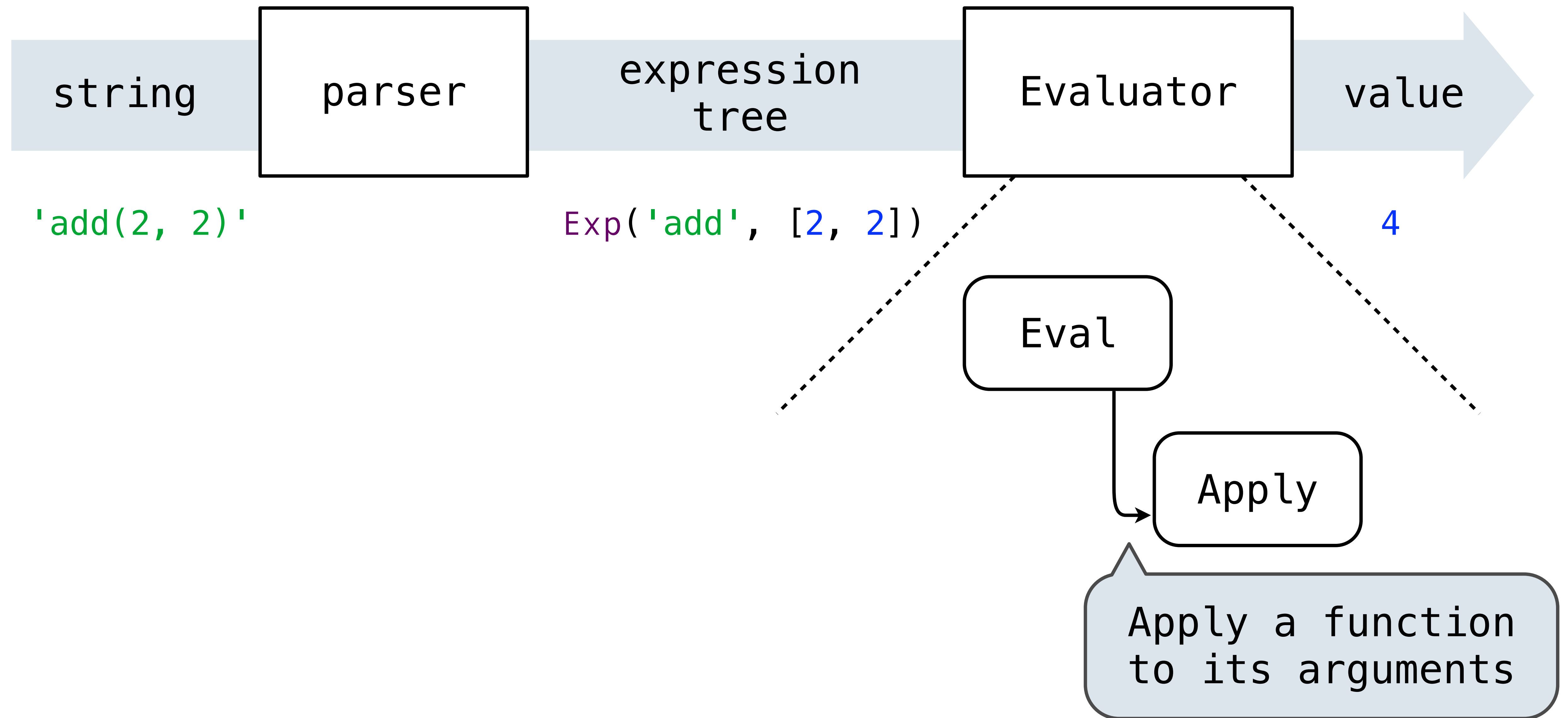

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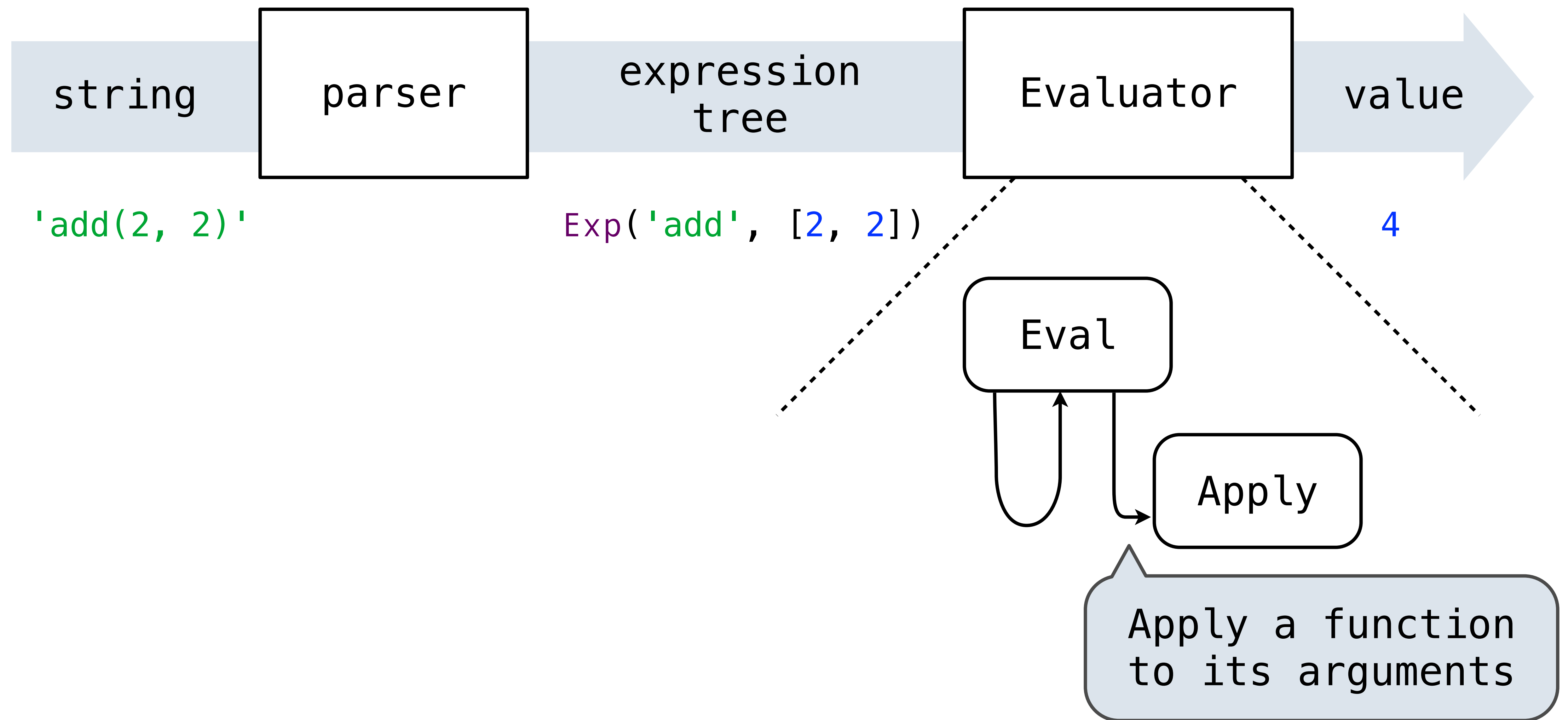

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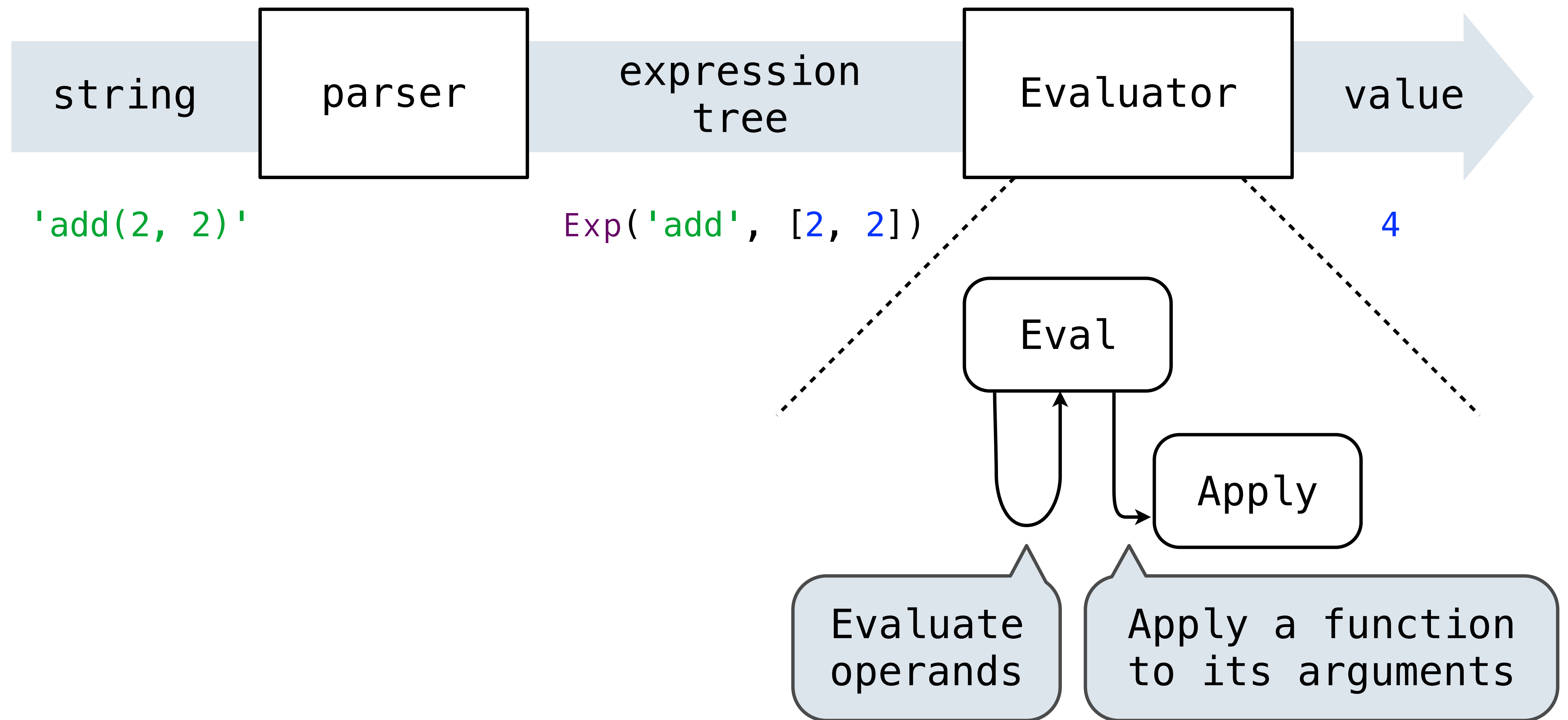

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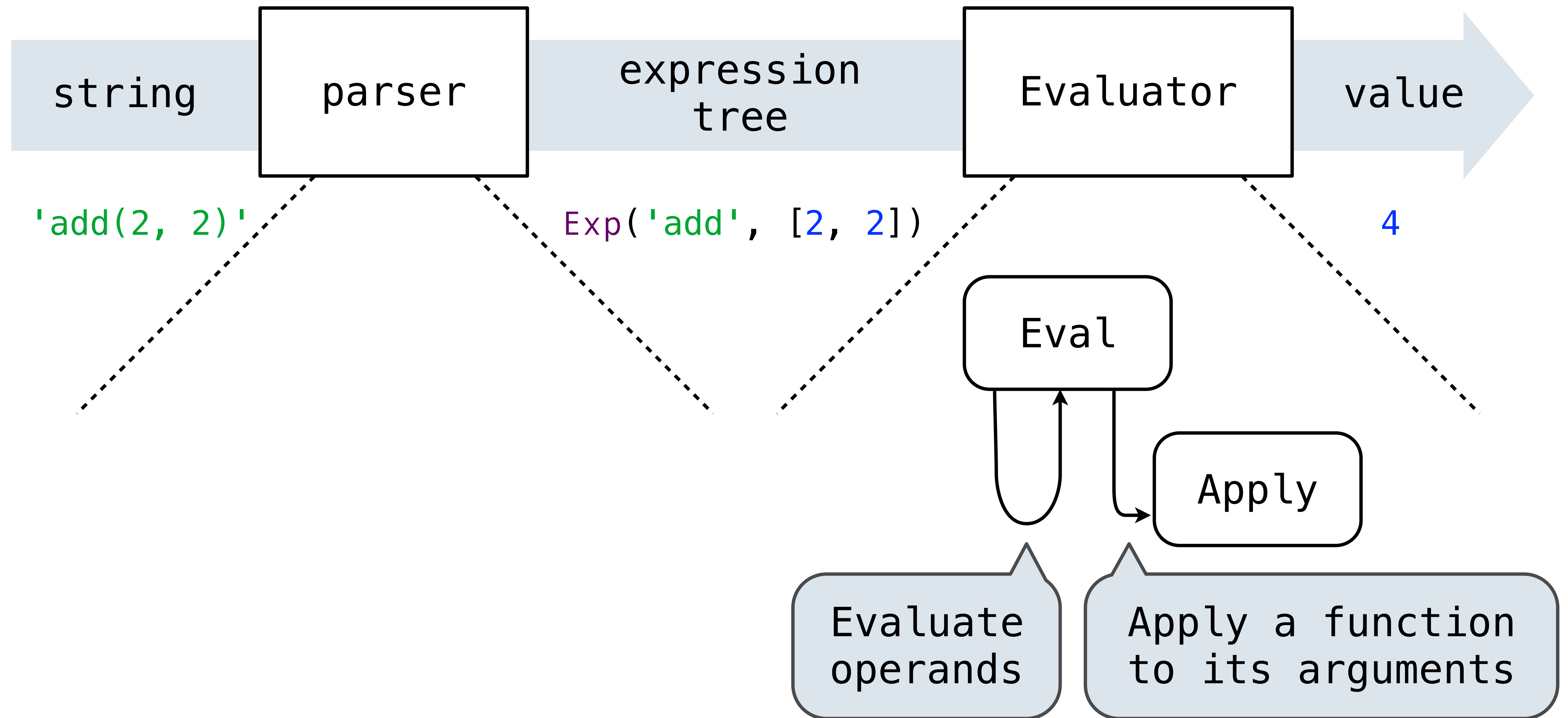

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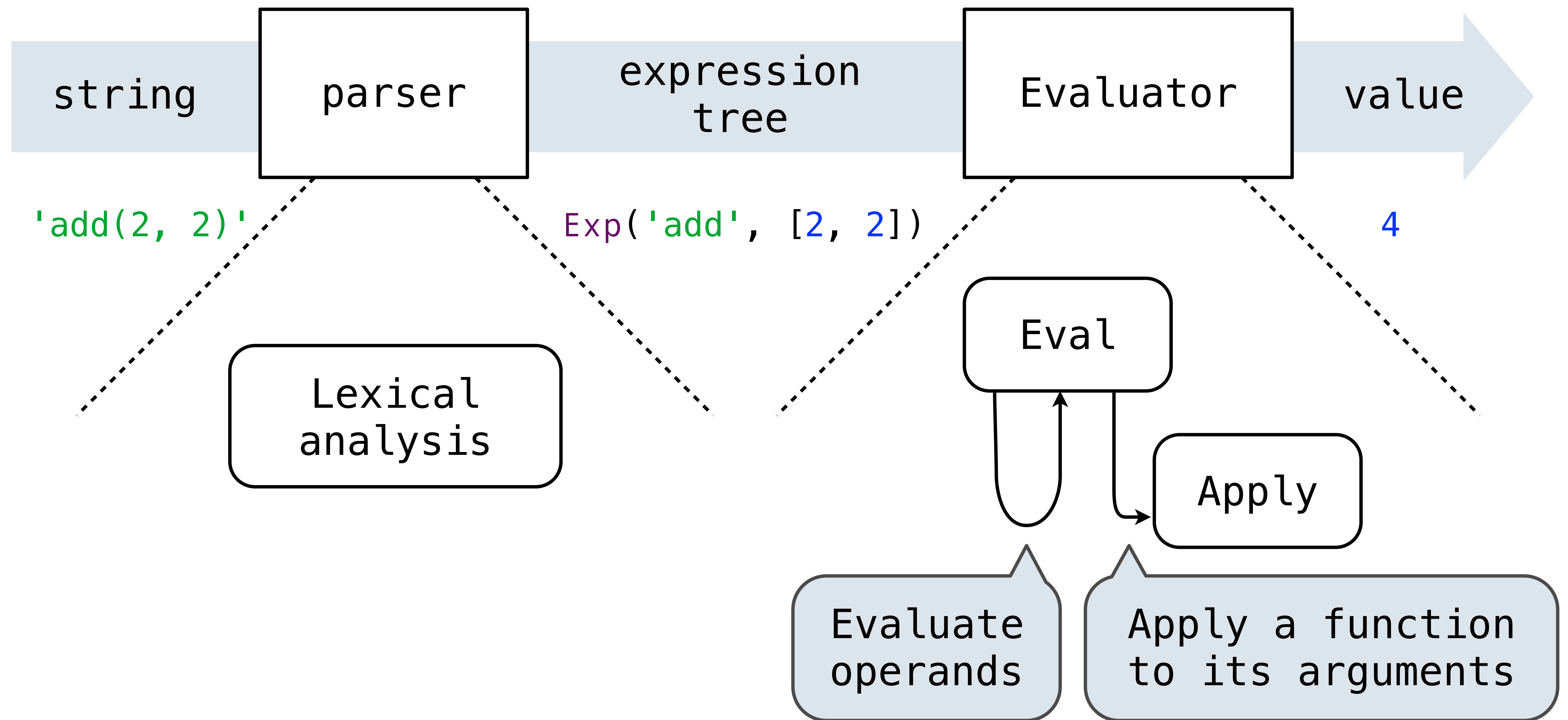

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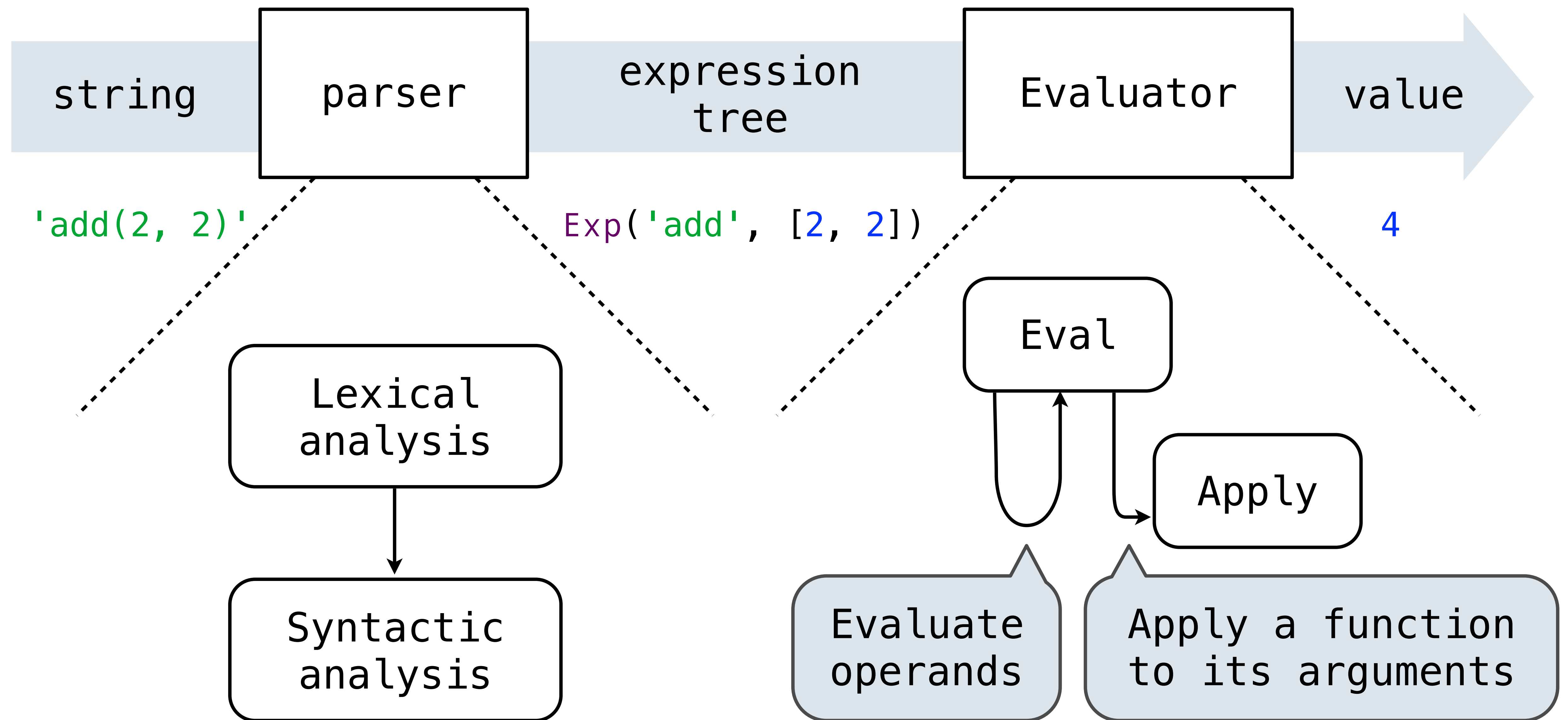

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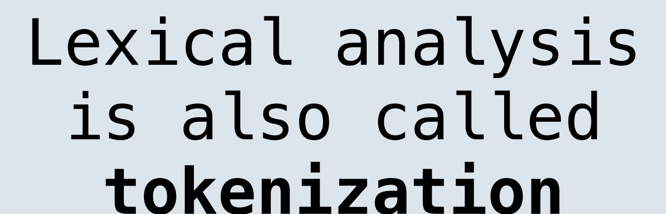

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def calc_parse(line):
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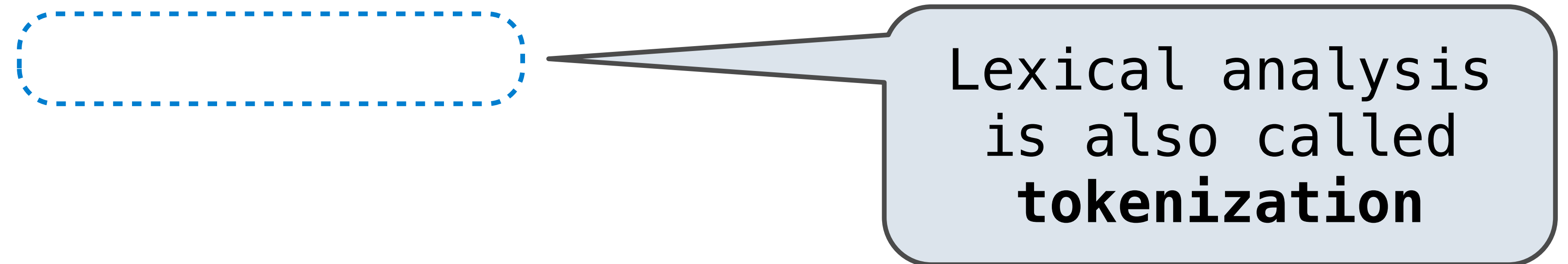
Lexical analysis is also called **tokenization**

Parsing with Local State

Lexical analyzer: Creates a list of tokens

Syntactic analyzer: Consumes a list of tokens



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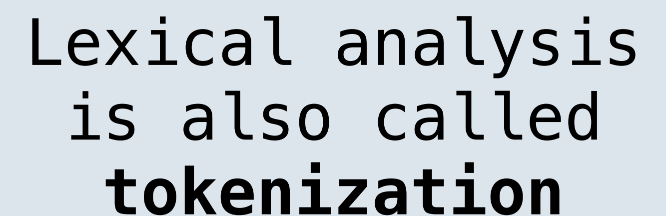

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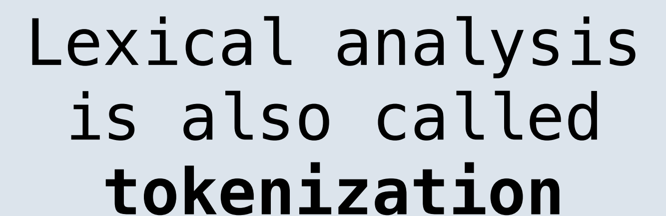

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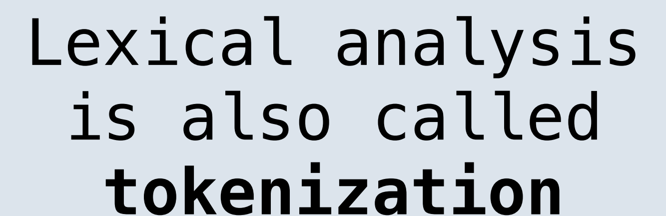

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(When viewed as a list of Calculator tokens)

Lexical Analysis By Inserting Spaces

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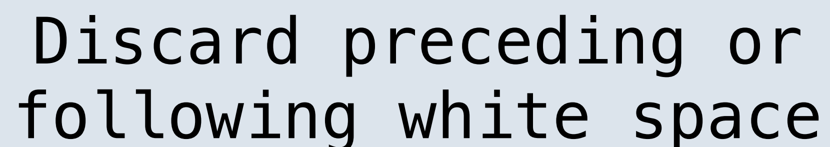

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Discard preceding or following white space

Return a list of strings separated by white space

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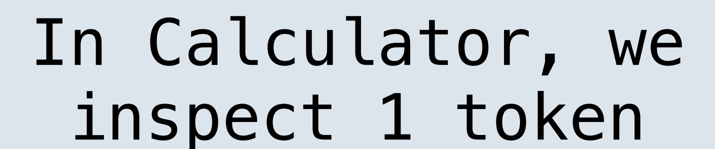

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tokens no longer includes first two elements

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def analyze_operands(tokens):
    operands = []
    while tokens[0] != ')':
        if operands:
            tokens.pop(0)  # Remove ,
        operands.append(analyze(tokens))
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    if type(token) in (int, float):
        return token
    else:
        tokens.pop(0)  # Remove (
        return Exp(token, analyze_operands(tokens))

def analyze_operands(tokens):
    operands = []
    while tokens[0] != ')':
        if operands:
            tokens.pop(0)  # Remove ,
        operands.append(analyze(tokens))
    tokens.pop(0)  # Remove )
```

Mutual Recursion in Analyze

```
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Mutual Recursion in Analyze

```
['add','(','2',',','3',')']
```

```
def analyze(tokens):
    token = analyze_token(tokens.pop(0))
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      ['(','2',',','3',')']
```

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Mutual Recursion in Analyze

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       ['(','2',',','3',')']        token = analyze_token(tokens.pop(0))
                                    if type(token) in (int, float):
                                        return token
                                    else:
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                                        return Exp(token, analyze_operands(tokens))

                               def analyze_operands(tokens):
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                                    while tokens[0] != ')':
                                        if operands:
                                            tokens.pop(0)  # Remove ,
                                        operands.append(analyze(tokens))
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['add','(','2',',','3',')']   def analyze(tokens):
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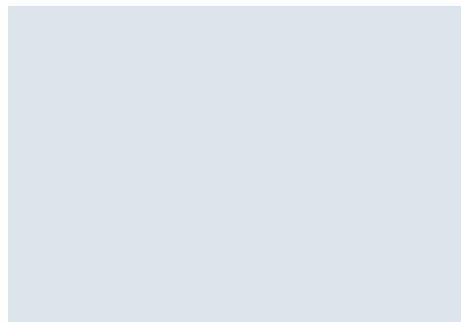
                                 tokens.pop(0)  # Remove )
                                 return operands
```

Pass 1



Mutual Recursion in Analyze

```
['add','(','2',',','3',')']   def analyze(tokens):
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                                  if type(token) in (int, float):
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                                  while tokens[0] != ')':
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                                          tokens.pop(0)  # Remove ,
                                      operands.append(analyze(tokens))
                                  tokens.pop(0)  # Remove )
                                  return operands
```

Pass 1

```
[',','3',')']
```

Mutual Recursion in Analyze

```
['add','(','2',',','3',')']    def analyze(tokens):
     ['(','2',',','3',')']         token = analyze_token(tokens.pop(0))
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                                       return token
                                   else:
         ['2',',','3',')']             tokens.pop(0)  # Remove (
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         ['2',',','3',')']     def analyze_operands(tokens):
                                   operands = []
                                   while tokens[0] != ')':
                                       if operands:
                                           tokens.pop(0)  # Remove ,
                                       operands.append(analyze(tokens))
                                   tokens.pop(0)  # Remove )
                                   return operands
```

Pass 1	Pass 2
[',','3',')']	

Mutual Recursion in Analyze

```
['add','(','2',',','3',')']   def analyze(tokens):
     ['(','2',',','3',')']        token = analyze_token(tokens.pop(0))
                                  if type(token) in (int, float):
                                      return token
                                  else:
         ['2',',','3',')']            tokens.pop(0)  # Remove (
                                      return Exp(token, analyze_operands(tokens))

         ['2',',','3',')']   def analyze_operands(tokens):
                                 operands = []
                                 while tokens[0] != ')':
                                     if operands:
                                         tokens.pop(0)  # Remove ,
                                     operands.append(analyze(tokens))
                                 tokens.pop(0)  # Remove )
                                 return operands
```

Pass 1

```
[',','3',')']
```

Pass 2

```
['3',')']
```

Mutual Recursion in Analyze

```
['add','(','2',',','3',')']   def analyze(tokens):
     ['(','2',',','3',')']        token = analyze_token(tokens.pop(0))
                                  if type(token) in (int, float):
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                                  else:
         ['2',',','3',')']            tokens.pop(0)  # Remove (
                                      return Exp(token, analyze_operands(tokens))

         ['2',',','3',')']    def analyze_operands(tokens):
                                  operands = []
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                                      if operands:
                                          tokens.pop(0)  # Remove ,
                                      operands.append(analyze(tokens))
                                  tokens.pop(0)  # Remove )
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```

Pass 1	Pass 2
	['3',')']
[',','3',')']	[')']

Mutual Recursion in Analyze

```
['add','(','2',',','3',')']    def analyze(tokens):
      ['(','2',',','3',')']        token = analyze_token(tokens.pop(0))
                                   if type(token) in (int, float):
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                                       if operands:
                                           tokens.pop(0)  # Remove ,
                                       operands.append(analyze(tokens))
                        []         tokens.pop(0)  # Remove )
                                   return operands
```

Pass 1	Pass 2
	['3',')']
[',','3',')']	[')']

Token Coercion

Token Coercion

```
Parsers typically identify the form of each expression,
so that eval can dispatch on that form
```

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In Calculator, the form is determined by the expression type

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```
def analyze_token(token):
```

Token Coercion

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```
def analyze_token(token):
    try:
```

Token Coercion

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```
def analyze_token(token):
    try:
        return int(token)
```

Token Coercion

Parsers typically identify the form of each expression,
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- Primitive expressions are int or float values
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```
def analyze_token(token):
    try:
        return int(token)
    except (TypeError, ValueError):
```

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def analyze_token(token):
    try:
        return int(token)
    except (TypeError, ValueError):
        try:
            return float(token)
```

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def analyze_token(token):
    try:
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    except (TypeError, ValueError):
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            return float(token)
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def analyze_token(token):
    try:
        return int(token)
    except (TypeError, ValueError):
        try:
            return float(token)
        except (TypeError, ValueError):
            return token
```

Token Coercion

Parsers typically identify the form of each expression, so that eval can dispatch on that form

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- Primitive expressions are int or float values
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```
def analyze_token(token):
    try:
        return int(token)
    except (TypeError, ValueError):
        try:
            return float(token)
        except (TypeError, ValueError):
            return token
```

What would change if we deleted this?

Error Handling: Analyze

Error Handling: Analyze

```
known_operators = ['add', 'sub', 'mul', 'div', '+', '-', '*', '/']
```

Error Handling: Analyze

```
known_operators = ['add', 'sub', 'mul', 'div', '+', '-', '*', '/']

def analyze(tokens):
```

Error Handling: Analyze

```
known_operators = ['add', 'sub', 'mul', 'div', '+', '-', '*', '/']

def analyze(tokens):
    assert_non_empty(tokens)
```

Error Handling: Analyze

```
known_operators = ['add', 'sub', 'mul', 'div', '+', '-', '*', '/']

def analyze(tokens):
    assert_non_empty(tokens)
    token = analyze_token(tokens.pop(0))
```

Error Handling: Analyze

```
known_operators = ['add', 'sub', 'mul', 'div', '+', '-', '*', '/']

def analyze(tokens):
    assert_non_empty(tokens)
    token = analyze_token(tokens.pop(0))
    if type(token) in (int, float):
        return token
```

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known_operators = ['add', 'sub', 'mul', 'div', '+', '-', '*', '/']

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    token = analyze_token(tokens.pop(0))
    if type(token) in (int, float):
        return token
    if token in known_operators:
```

Error Handling: Analyze

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known_operators = ['add', 'sub', 'mul', 'div', '+', '-', '*', '/']

def analyze(tokens):
    assert_non_empty(tokens)
    token = analyze_token(tokens.pop(0))
    if type(token) in (int, float):
        return token
    if token in known_operators:
        if len(tokens) == 0 or tokens.pop(0) != '(':
            raise SyntaxError('expected ( after ' + token)
```

Error Handling: Analyze

```
known_operators = ['add', 'sub', 'mul', 'div', '+', '-', '*', '/']

def analyze(tokens):
    assert_non_empty(tokens)
    token = analyze_token(tokens.pop(0))
    if type(token) in (int, float):
        return token
    if token in known_operators:
        if len(tokens) == 0 or tokens.pop(0) != '(':
            raise SyntaxError('expected ( after ' + token)
        return Exp(token, analyze_operands(tokens))
```

Error Handling: Analyze

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known_operators = ['add', 'sub', 'mul', 'div', '+', '-', '*', '/']

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    assert_non_empty(tokens)
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    if type(token) in (int, float):
        return token
    if token in known_operators:
        if len(tokens) == 0 or tokens.pop(0) != '(':
            raise SyntaxError('expected ( after ' + token)
        return Exp(token, analyze_operands(tokens))
    else:
        raise SyntaxError('unexpected ' + token)
```

Error Handling: Analyze Operands

Error Handling: Analyze Operands

```
def analyze_operands(tokens):
```

Error Handling: Analyze Operands

```
def analyze_operands(tokens):
    assert_non_empty(tokens)
```

Error Handling: Analyze Operands

```
def analyze_operands(tokens):
    assert_non_empty(tokens)
    operands = []
```

Error Handling: Analyze Operands

```
def analyze_operands(tokens):
    assert_non_empty(tokens)
    operands = []
    while tokens[0] != ')':
```

Error Handling: Analyze Operands

```
def analyze_operands(tokens):
    assert_non_empty(tokens)
    operands = []
    while tokens[0] != ')':
        if operands and tokens.pop(0) != ',':
            raise SyntaxError('expected ,')
```

Error Handling: Analyze Operands

```
def analyze_operands(tokens):
    assert_non_empty(tokens)
    operands = []
    while tokens[0] != ')':
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        operands.append(analyze(tokens))
```

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        operands.append(analyze(tokens))
        assert_non_empty(tokens)
```

Error Handling: Analyze Operands

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def analyze_operands(tokens):
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        operands.append(analyze(tokens))
        assert_non_empty(tokens)
    tokens.pop(0)  # Remove )
```

Error Handling: Analyze Operands

```
def analyze_operands(tokens):
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    operands = []
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        if operands and tokens.pop(0) != ',':
            raise SyntaxError('expected ,')
        operands.append(analyze(tokens))
        assert_non_empty(tokens)
    tokens.pop(0)  # Remove )
    return elements
```

Error Handling: Analyze Operands

```
def analyze_operands(tokens):
    assert_non_empty(tokens)
    operands = []
    while tokens[0] != ')':
        if operands and tokens.pop(0) != ',':
            raise SyntaxError('expected ,')
        operands.append(analyze(tokens))
        assert_non_empty(tokens)
    tokens.pop(0)  # Remove )
    return elements

def assert_non_empty(tokens):
    """Raise an exception if tokens is empty."""
    if len(tokens) == 0:
        raise SyntaxError('unexpected end of line')
```

Let's Break the Calculator

Let's Break the Calculator

```
I delete a statement that raises an exception
```

Let's Break the Calculator

```
I delete a statement that raises an exception

You find an input that will crash Calculator
```