# Lecture 5 – Parsing

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# What is parsing?

**Parsing**

- A process of analysing a piece of text to determine its *syntactic structure*.

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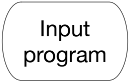
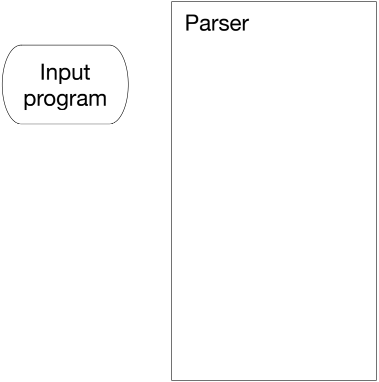
- A process of analysing a piece of text to determine its *syntactic structure*.

**Parser**

- A program that makes such syntactic analyses
  - takes some input data, usually text (e.g., program)
  - builds a data structure, like parse tree, abstract syntax tree

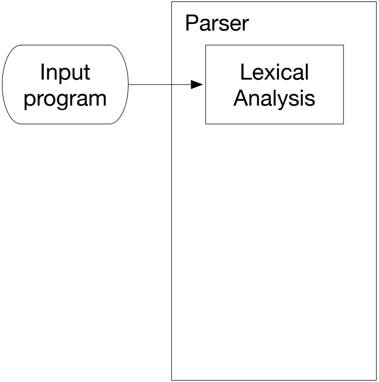

Input
program

# Parsing a program



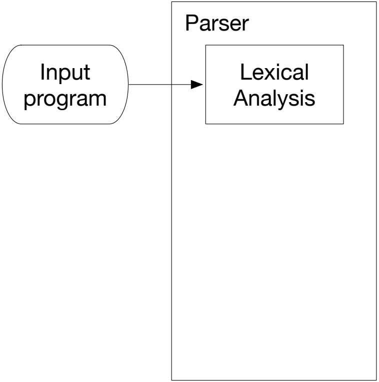

**Two steps**

# Parsing a program




**Lexical Analysis (lexer)**

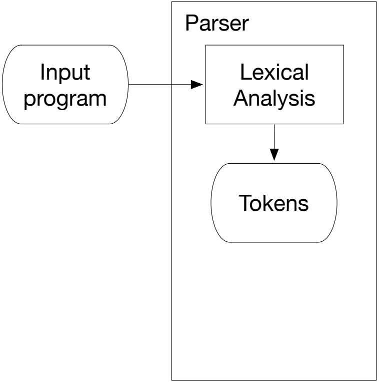
# Parsing a program




**Lexical Analysis (lexer)**

– Split into meaningful terminals

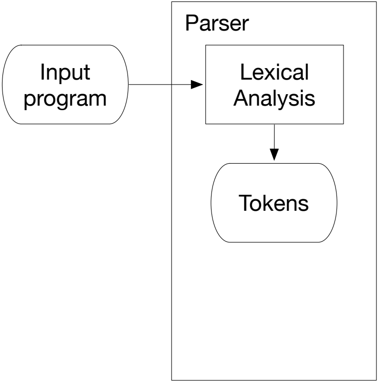
# Parsing a program




**Lexical Analysis (lexer)**

– Split into meaningful terminals

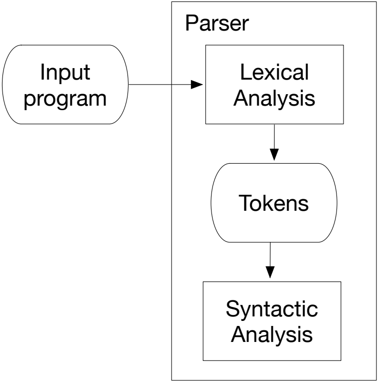
# Parsing a program




**Lexical Analysis (lexer)**

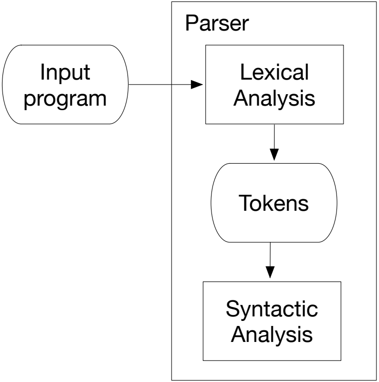
– Split into meaningful terminals

E.g.: "3 + 2" $\rightarrow$ "3", "+", "2"




**Syntactic Analysis**

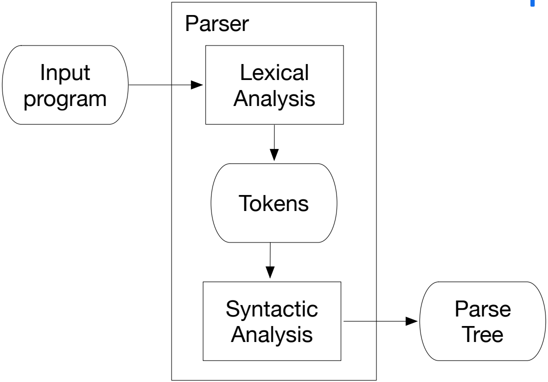
# Parsing a program




**Syntactic Analysis**

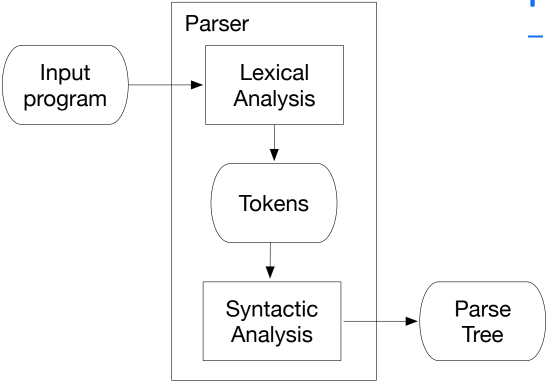
– Check whether the tokens form an illegal expression

# Parsing a program




**Parse tree**

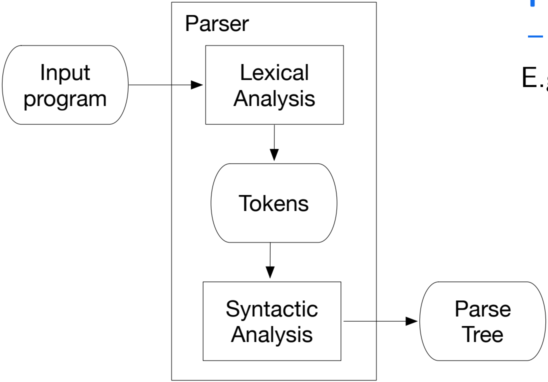
# Parsing a program




**Parse tree**

– A data structure

# Parsing a program

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E.g.: "3", "+", "2"

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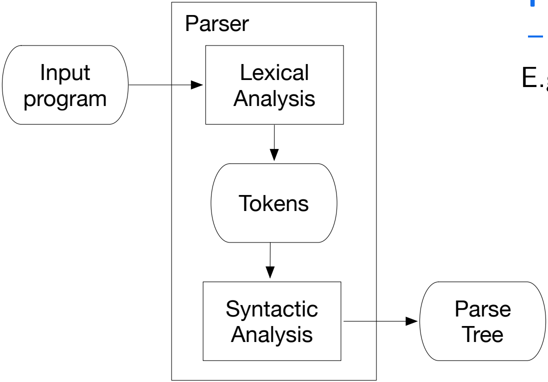


**Parse tree**

– A data structure

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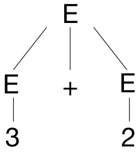
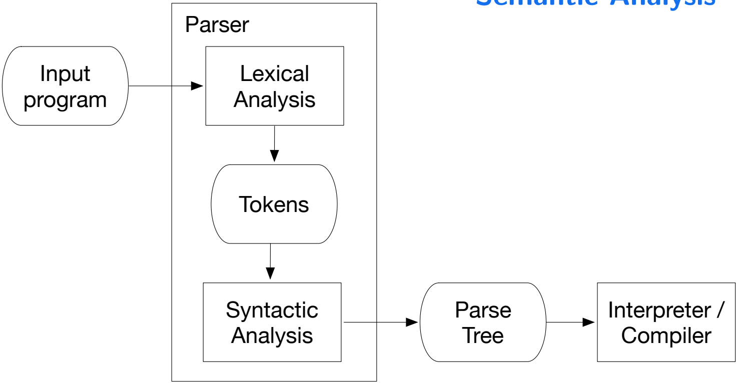


# Parsing a program

**Semantic Analysis**



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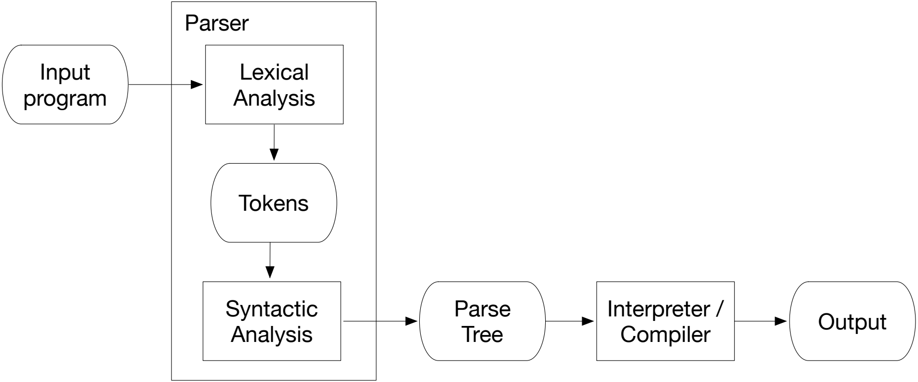

# Parsers

**Task**

- To decide whether an input *can be* derived and *how* to derive from a starting symbol

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Mainly two ways:

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- Top-down
  - start from the starting non-terminal
  - pick a production rule and try to match the input string
  - attempt to find the leftmost derivation
  - may require *backtracking*
  - predictive grammar $\leftarrow$ no backtracking
- Bottom-up

**Task**

- To decide whether an input *can be* derived and *how* to derive from a starting symbol

Mainly two ways:

- Top-down
  - start from the starting non-terminal
  - pick a production rule and try to match the input string
  - attempt to find the leftmost derivation
  - may require *backtracking*
  - predictive grammar $\leftarrow$ no backtracking
- Bottom-up
  - start from the input string
  - locate the most basic elements, then
  - find the elements containing those identified ones, until
  - the starting non-terminal is reached

To parse "a * b + c"

expression ::= term | expression add term

term ::= operand | term multi operand

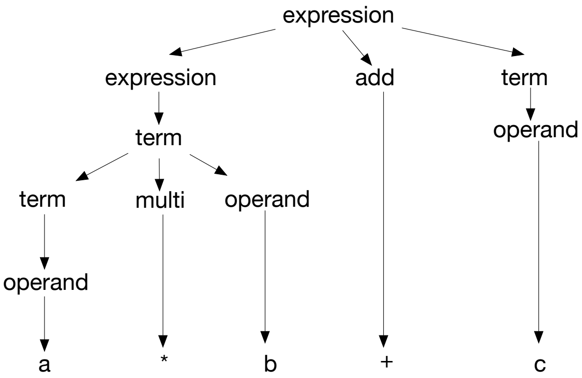
operand ::= a | b | c

add ::= +

mulit ::= *

# Top-down parsing

To parse "a * b + c"

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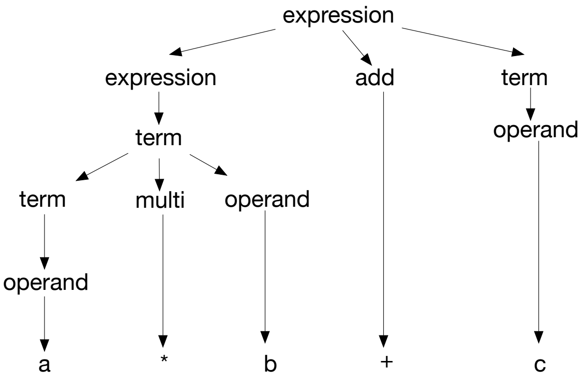


– Recursive descent parser
– LL parser

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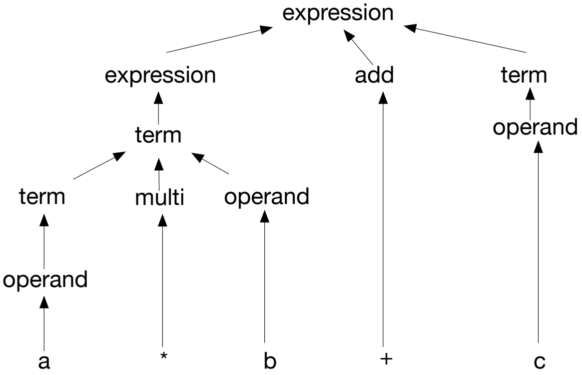


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# Bottom-up parsing

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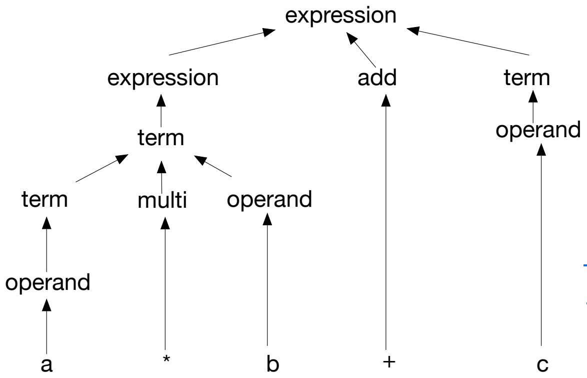


– Shift-reduce parser
– LR parser

expression ::= term | expression add term

term ::= operand | term multi operand

operand ::= a | b | c

add ::= +

mulit ::= *

# Some useful functions

```
takeWhile ::
```

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```
takeWhile ::
takeWhile (< 4) [1,2,1,4,1,2,3,4]
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dropWhile :: (a -> Bool) -> [a] -> [a]
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dropWhile _ []          =  []
dropWhile p xs@(x:xs')
          | p x         =  dropWhile p xs'
          | otherwise =  xs
```

# Some useful functions

```
id ::
```

# Some useful functions

```
id ::
id 3
```

# Some useful functions

```
id ::
id 3.......................................................3
```

# Some useful functions

```
id ::
id 3.......................................................3
id (1,2)
```

# Some useful functions

```
id ::
id 3......................................................3
id (1,2) ..........................................(1,2)
```

# Some useful functions

```
id :: a -> a                                        identity function
id 3.....................................................3
id (1,2)............................................(1,2)
```

# Some useful functions

```
id :: a -> a                                        identity function
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const ::
```

# Some useful functions

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const ::
const 1 2
```

# Some useful functions

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id :: a -> a                          identity function
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const ::
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const 10 'a'
```

# Some useful functions

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id :: a -> a                                   identity function
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# Some useful functions

```
id :: a -> a                                  identity function
id 3........................................................3
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const :: a -> b -> a                          constant function
const 1 2...................................................1
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```

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```
id :: a -> a                          identity function
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const 1 ::
```

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const 1 :: ???
```

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const 1 ::          b -> a
```

# Some useful functions

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const 1 :: Num a => b -> a
```

# Example – a dictionary

**As a list of pairs**

`type Dict = [(Key, Value)]` for some types `Key` and `Value`

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type Dict = Key -> Value

emptyDict ::
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**As a function**

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type Dict = Key -> Value
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```
emptyDict :: Dict
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`type Dict = [(Key, Value)]` for some types `Key` and `Value`

**As a function**

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type Dict = Key -> Maybe Value
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```
lookup ::
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lookup d k =
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type Dict = Key -> Maybe Value

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lookup :: Dict -> Key -> Maybe Value
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add :: Dict -> Key -> Value -> Dict
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```

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add :: Dict -> Key -> Value -> Dict
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# Lexical analysis – tokenize :: String -> [String]

- "012 * (3 + 11)" must be divided into meaningful substrings (tokens)

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# Recursive descent parsing

Grammar: starting symbol E,

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| 5) | | T / F |
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| 10) | F ::= | Int |
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parseG                                                   G::= -G|F
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         else (a,z)                                     – error “expect *”
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  - E.g., E ::= E + T | T ,     T ::= Int

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- LL(k) parsers does not require backtracking