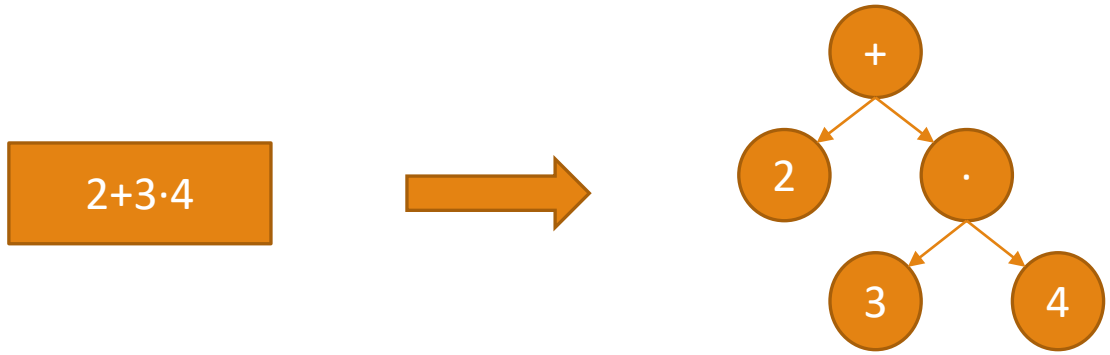
Parser

Parser

Program koji analizira tekst i određuje njegovu sintaksnu strukturu



Svaki kompajler, interpreter, OS, brauzer,…. mora imati parser

```
type Parser = String -> Tree
```

Ovako definisan parser je “Black Box”

```
type Parser = String -> (Tree, String)
```

Vraća drvo i deo ulaza koji nije obrađen

Parser

Šta ako ulaz nije moguće parsirati u slučaju greške?

```
data Maybe                  ~> [ ]
     | Just a               ~> [a]
```

```
type Parser = String -> [(Tree, String)]
```

Različiti parseri će vratiti različite tipove stabla ili neku drugu vrednost

```
type Parser a = String -> [(a, String)]
```

Osnovni parser

```
import Control.Applicative
import Data.Char
```

Da bismo Parser koristili kao instancu klase koristićemo dummy konstruktor

```
newtype Parser a = P (String -> [(a,String)])
```

Ovakav parser se primenjuje na ulazni string korišćenjem funkcije koja uklanja konstruktor

```
parse :: Parser a -> String -> [(a,String)]
parse (P p) inp = p inp
```

Osnovni parser

Prvi karakter ulaza

```
item :: Parser Char
item = P (\inp -> case inp of
          [] -> []
          (x:xs) -> [(x,xs)])
```

```
ghci> parse item ""
[]
ghci> parse item "abc"
[('a',"bc")]
```

Parseri sekvenci

Parser kao instanca funktora

```
instance Functor Parser where
  -- fmap :: (a -> b) -> Parser a -> Parser b
  fmap g p = P (\inp -> case parse p inp of
                 [] -> []
                 [(v,out)] -> [(g v, out)])
```

```
ghci> parse (fmap toUpper item) "abc"
[('A',"bc")]
ghci> parse (fmap toUpper item) ""
[]
```

Parseri sekvenci

Parser kao instanca aplikativnog funktora

```
instance Applicative Parser where
  -- pure :: a -> Parser a
  pure v = P (\inp -> [(v,inp)])
  -- <*> :: Parser (a -> b) -> Parser a -> Parser b
  pg <*> px = P (\inp -> case parse pg inp of
                  [] -> []
                  [(g,out)] -> parse (fmap g px) out)
```

```
three :: Parser (Char,Char)
three = pure g <*> item <*> item <*> item
          where g x y z = (x,z)
```

```
ghci> parse (pure 1) "abc"
[(1,"abc")]
ghci> parse three "abcdef"
[(('a','c'),"def")]
ghci> parse three "ab"
[]
```

Parseri sekvenci

Parser kao instanca aplikativnog monada

```
instance Monad Parser where
  -- (>>=) :: Parser a -> (a -> Parser b) -> Parser b
  p >>= f = P (\inp -> case parse p inp of
                [] -> []
                [(v,out)] -> parse (f v) out)
```

```
three' :: Parser (Char,Char)
three' = do
            x <- item
            item
            z <- item
            return (x,z)
```

Donešenje odluka

Donošenje odluka nije specifično za parser, ali može da se generalizuje aplikativne tipove

```
class Applicative f => Alternative f where
  empty :: f a
  (<|>) :: f a -> f a -> f a

instance Alternative Maybe where
  empty :: Maybe a
  empty = Nothing

  (<|>) :: Maybe a -> Maybe a -> Maybe a
  Nothing <|> my = my
  (Just x) <|> _ = Just x
```

Donošenje odluka

```
instance Alternative Parser where
  -- empty :: Parser a
  empty = P (\inp -> [])
  -- (<|>) :: Parser a -> Parser a -> Parser a
  p <|> q = P (\inp -> case parse p inp of
                [] -> parse q inp
                [(v,out)] -> [(v,out)])
```

```
ghci> parse empty "abc"
[]
ghci> parse (item <|> return 'd') "abc"
[('a',"bc")]
ghci> parse (empty <|> return 'd') "abc"
[('d',"abc")]
```

Izvedeni tipovi

```
sat :: (Char -> Bool) -> Parser Char
sat p = do
           x <- item
           if p x then return x else empty
```

```
digit :: Parser Char
digit = sat isDigit

lower :: Parser Char
lower = sat isLower

upper :: Parser Char
upper = sat isUpper
```

```
letter :: Parser Char
letter = sat isAlpha

alphanum :: Parser Char
alphanum = sat isAlphaNum

char :: Char -> Parser Char
char x = sat (== x)
```

Izvedeni tipovi

```
string :: String -> Parser String
string [] = return []
string (x:xs) = do
                  char x
                  string xs
                  return (x:xs)
```

```
ghci> parse (char 'a') "abc"
[('a',"bc")]
ghci> parse (string "abc") "abcdef"
[("abc","def")]
ghci> parse (string "abc") "ab1234"
[]
```

```
ghci> parse (many digit) "123abc"
[("123","abc")]
ghci> parse (many digit) "abc"
[("","abc")]
ghci> parse (some digit) "abc"
[]
```

Izvedeni tipovi

```
ident :: Parser String
ident = do
          x <- lower
          xs <- many alphanum
          return (x:xs)
```

```
nat :: Parser Int
nat = do
        xs <- some digit
        return (read xs)
```

```
ghci> parse ident "abc def"
[("abc"," def")]
ghci> parse nat "123 abc"
[(123," abc")]
```

Izvedeni tipovi

```
space :: Parser ()
space = do
          many (sat isSpace)
          return ()
```

```
int :: Parser Int
int = do
        char '-'
        n <- nat
        return (-n)
      <|> nat
```

```
ghci> parse space " abc"
[((),"abc")]
ghci> parse int "-123 abc"
[(-123," abc")]
```

Obrada belina

```
token :: Parser a -> Parser a
token p = do
            space
            v <- p
            space
            return v
```

```
identifier :: Parser String
identifier = token ident
```

```
natural :: Parser Int
natural = token nat
```

```
integer :: Parser Int
integer = token int
```

```
symbol :: String -> Parser String
symbol xs = token (string xs)
```

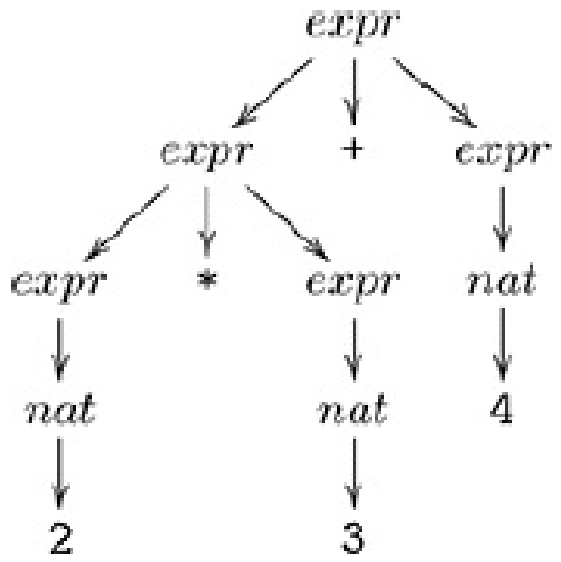
Aritmetički izrazi

expr ::= expr + expr | expr * expr | (expr) | nat

nat ::= 0 | 1 | 2 | …

Ovako definisana gramatika ne uzima u obzir činjenucu da je * većeg prioriteta od +

2 * 3 + 4



Aritmetički izrazi

expr ::= expr + expr | term

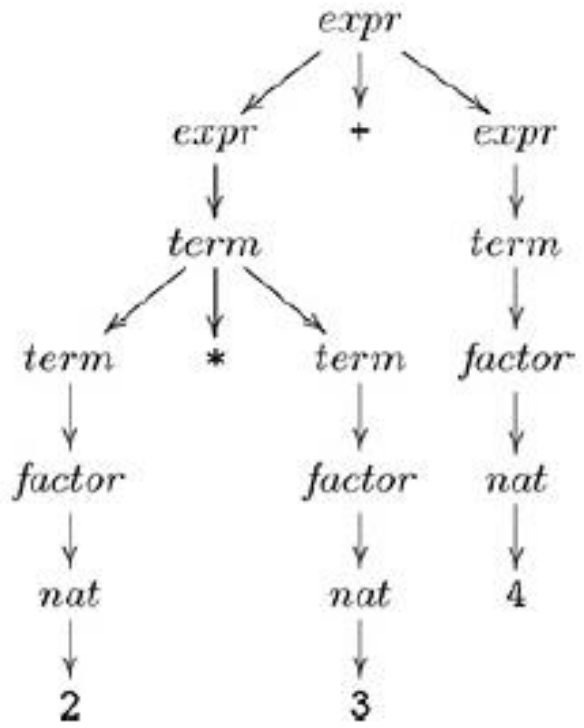
term ::= term * term | factor

factor ::= (expr) | nat

nat ::= 0 | 1 | 2 | …

Prioritet je rešen, ali nije uzeta u obzir desna asocijativnost za * i +

2 * 3 + 4



Aritmetički izrazi

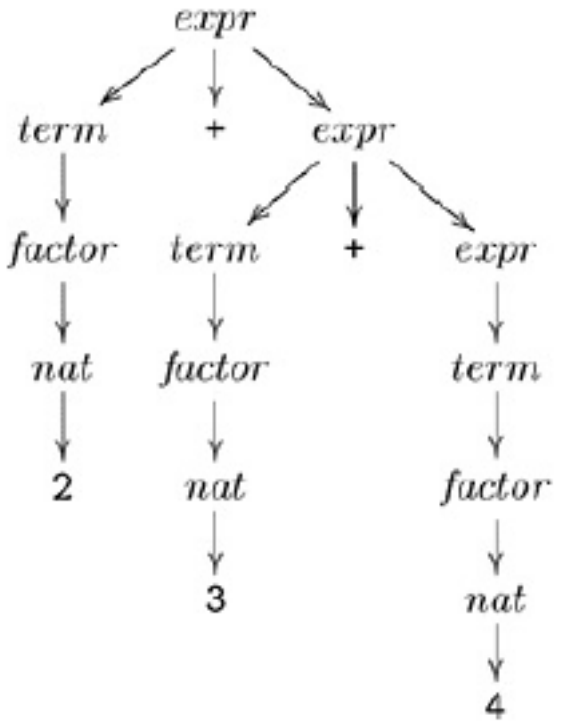
expr ::= term + expr | term

term ::= factor * term | factor

factor ::= (expr) | nat

nat ::= 0 | 1 | 2 | …

2 + 3 + 4



Dobijena gramatika je nedvosmislena

Aritmetički izrazi

expr ::= term (+ expr | ε)

term ::= factor (* term | ε)

factor ::= (expr) | nat

nat ::= 0 | 1 | 2 | …

```
expr :: Parser Int
expr = do
         t <- term
         do
            symbol "+"
            e <- expr
            return (t + e)
            <|> return t
```

```
term :: Parser Int
term = do
         f <- factor
         do
             symbol "*"
             t <- term
             return (f * t)
             <|> return f
```

```
factor :: Parser Int
factor = do
             symbol "("
             e <- expr
             symbol ")"
             return e
         <|> natural
```

Aritmetički izrazi

```
eval' :: String -> Int
eval' xs = case (parse expr xs) of
             [(n,[])]  -> n
             [(_,out)] -> error ("Unused input " ++ out)
             []        -> error "Invalid input"
```

```
ghci> eval' "2*3+4"
10
ghci> eval' "2*(3+4)"
14
```

```
ghci> eval' "2*3^4"
*** Exception: Unused input ^4
CallStack (from HasCallStack):
  error, called at parser.hs:176:27 in main:Main
ghci> eval' "one plus two"
*** Exception: Invalid input
CallStack (from HasCallStack):
  error, called at parser.hs:177:27 in main:Main
```

Kalkulator

```
box :: [String]
box = ["+---------------+",
       "|               |",
       "+---+---+---+---+",
       "| q | c | d | = |",
       "+---+---+---+---+",
       "| 1 | 2 | 3 | + |",
       "+---+---+---+---+",
       "| 4 | 5 | 6 | - |",
       "+---+---+---+---+",
       "| 7 | 8 | 9 | * |",
       "+---+---+---+---+",
       "| 0 | ( | ) | / |",
       "+---+---+---+---+"]
```

Kalkulator

```
buttons :: String
buttons = standard ++ extra
   where
      standard = "qcd=123+456-789*0()/"
      extra = "QCD \ESC\BS\DEL\n"
```

```
showbox :: IO ()
showbox = sequence_ [writeAt (1,y) b | (y,b) <- zip [1..] box]
```

```
display xs = do
               writeAt (3,2) (replicate 13 ' ')
               writeAt (3,2) (reverse (take 13 (reverse xs)))
```

Kalkulator

```
calc :: String -> IO ()
calc xs = do
            display xs
            c <- getCh
            if elem c buttons then
                  process c xs
            else
                  do
                    beep
                    calc xs
```

```
process :: Char -> String -> IO ()
process c xs | elem c "qQ\ESC"  = quit
             | elem c "dD\BS\DEL" = delete xs
             | elem c "=\n"       = eval xs
             | elem c "cC"        = clear
             | otherwise          = press c xs
```

Kalkulator

```
quit :: IO ()
quit = goto (1,14)
```

```
delete :: String -> IO ()
delete [] = calc []
delete xs = calc (init xs)
```

```
eval :: String -> IO ()
eval xs = case parse expr xs of
            [(n,[])]  -> calc (show n)
            _         -> do
                           beep
                           calc xs
```

Kalkulator

```
clear :: IO ()
clear = calc []
```

```
press :: Char -> String -> IO ()
press c xs = calc (xs ++ [c])
```

```
run :: IO ()
run = do
        cls
        showbox
        clear
```