Compiler Construction

AST in C++

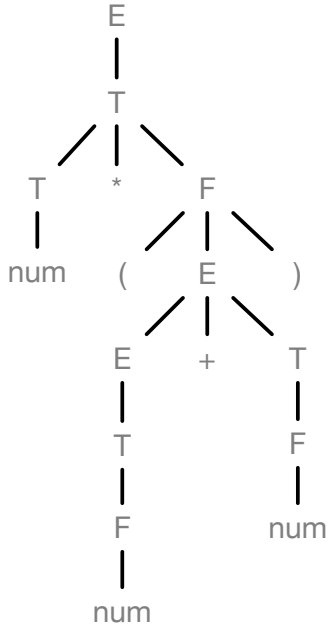
Simple Unambiguous Concrete Grammar (BNF)

```
<E> ::= <E> "+" <T>
      | <E> "-" <T>
      | <T>.
<T> ::= <T> "*" <F>
      | <T> "/" <F>
      | <F>.
<F> ::= "(" <E> ")"
      | <num>.
```

- **E** stands for expression
- **T** stands for term
- **F** stands for factor

Conventionally, terms are things you add, factor are things you multiply

Parse Tree: 1*(2+3)



A need for abstraction

Parse tree are not adapted (even if we could write a whole compiler with them):

- they retain syntactic information (punctuation symbols, ...)
- they reflect the underlying grammar
- they have redundant information: parenthesis and tree child for instance

All these elements could clutter the semantic analysis!

Abstract Gramnar (RTG)

RTG

A regular tree grammar (RTG) is a formal grammar used to describe trees

```
<exp> ::= Add(<exp>, <exp>)
        |  Sub(<exp>, <exp>)
        |  Mul(<exp>, <exp>)
        |  Div(<exp>, <exp>)
        |  Num(<num>).
```

AST

Abstract Syntax Tree

An AST is the translation of the parse tree in order to match the abstract grammar.

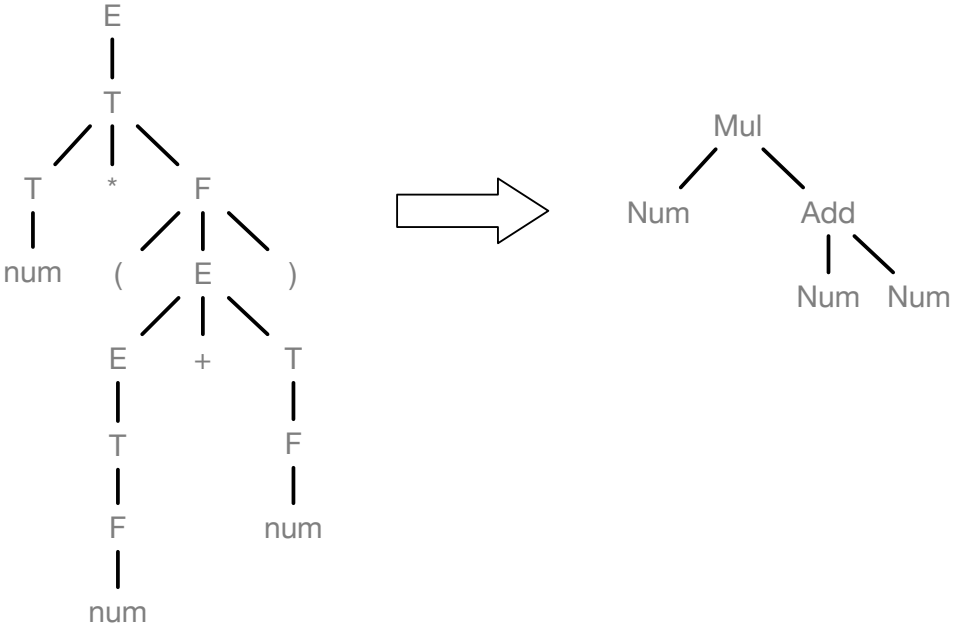
From Parse trees to AST

The translation from parse tree to AST is straightforward!

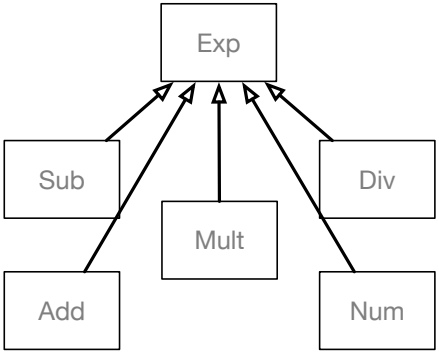
⇒ Just use production rules of the parser

```
exp:
   exp "+" term
     {
      $$ = new Add($1, $3);
     }
```

From Parse tree to AST



First AST Hierarchy

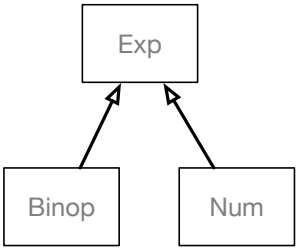


BAD OO Design!

Sub, Add, Div and Mult share a lot !

$\Rightarrow$ Refactor it!

Refined AST Hierarchy



C++ code (1/3)

```
class Exp
{
protected:
  // default constructor
  Exp() = default;

  // default copy-constructor
  Exp(const Exp& e) = default;

  // default assign operator
  Exp& operator=(const Exp& e)
       = default;

public:
  virtual ~Exp();
};
```

C++ code (2/3)

```
class Num : public Exp
{
public:
  Num(int val)
    : Exp(), val_(val)
  {}

private:
  int val_;
};
```

C++ code (3/3)

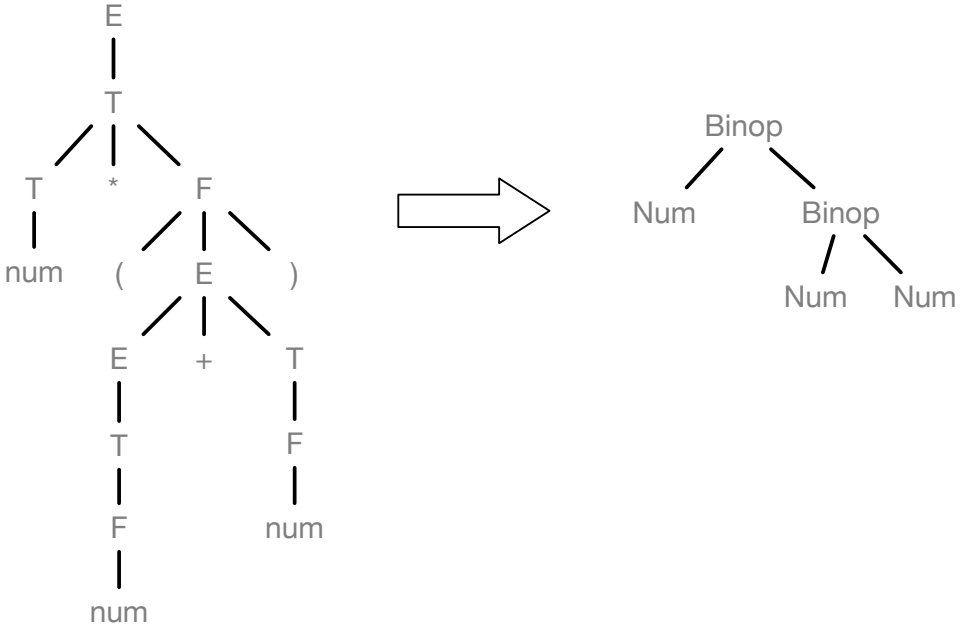
```
class Binop : public Exp
{
public:
   Binop(char oper,
         Exp* lhs, Exp* rhs)
  : Exp(), oper_(oper),
    lhs_(lhs), rhs_(rhs)
  {}

  ~Binop() override
  { delete lhs_; delete rhs_; }

private:
  char oper_; // Ugly !
  Exp* lhs_; Exp* rhs_;
};
```

Constructing an AST

```
int
main()
{
  Exp* tree =
       new Bin('+',
               new Num(42),
               new Num(51));
  delete tree;
}
```

Memory reclamation is (transitively) done through destructors

From Parse tree to refined AST



Summary