1EE Compiladores (IF688) – 2013.1 – Prof. Marcelo d'Amorim – 26 de Julho de 2013

Aluno:\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_

1. (2,0) Associe as tarefas abaixo com o componente correspondente do compilador: análise léxica (L), análise sintática (Si), semântica (Se), todas anteriores (T), ou nenhuma das anteriores (-).

|  |  |
| --- | --- |
| Si | Verifica se o “else” aparece sempre depois de um “if” |
| L | É especificada utilizando expressões regulares |
| Si | É especificada utilizando gramáticas livre de contexto (BNF / EBNF) |
| L | Lê o arquivo de entrada e gera tokens |
| Si | Cria a abstract syntax tree na memória |
| Si | Recebe os tokens como entrada |
| Se | Verifica se uma variável foi declarada antes de ser utilizada |
| T | Faz parte do front-end de um compilador |
| Si | Levanta um erro se uma keyword (e.g., “int”) é usada onde se espera um identificador |
| - | Realiza otimização de código |

1. (2,0) Sobre verificação de tipos (análise semântica), marque as afirmativas verdadeiras.

|  |  |
| --- | --- |
| F | Só pode ser feita de forma estática (estática ou dinâmica) |
| V | Coerções de tipo podem ser detectadas e inseridas pelo próprio compilador (por exemplo de int para float) |
| F | É possível garantir estaticamente que todos os acessos a arrays são feitos dentro dos limites do tamanho do array (dinamicamente apenas) |
| V | Um checador de tipos pode reportar um erro que não seja um erro (o compilador faz uma análise conservadora, por isso pode indicar erros que na verdade não são erros, “pecando por excesso” para sempre indicar possíveis erros. ex.: indicar a necessidade de uso de um tipo mais geral) |
| F | É comum um checador de tipos deixar escapar um erro que se propõe a detectar (vide explicação do item anterior) |
| V | Uma gramática de atributos pode ser usada para descrever um sistema de tipo simples |
| V | O padrão de projeto Visitor pode ser usado para implementar um sistema de tipo simples |
| V | A checagem de tipos dinâmica pode onerar o tempo de execução de um programa |



Obs.: falso negativos e falso positivos em checagem de tipos (no compilador só pode haver falso postivo):

**Dada a gramática abaixo, responda as questões seguintes**

Program : Statement ";" Program ***Program***

| /\* producao vazia \*/

;

Statement : "if" Expression "then" Statement "else" Statement ***IfStatement***

| IDENTIFIER "=" Expression ***AssignmentStatement***

;

Expression : IDENTIFIER ***Id***

| NUMBER ***Literal***

| Expression "+" Expression ***Add***

;

1. (2.0) A gramática acima possui recursão à esquerda? Explique e, em caso afirmativo, indique em qual ou quais produções. Em caso positivo, apresente uma versão sem recursão à esquerda. A gramática acima é ambígua? Explique, e, em caso afirmativo, indique em qual ou quais produções. Apresente uma versão sem ambiguidades e recursão à esquerda.

Sim, possui recursão à esquerda na produção Expression -> Expression “+” Expression.

Versão 1:

Expression : Exp1

| Exp1 "+" Expression

;

Exp1: IDENTIFIER

| NUMBER

;

Versão 2:

Expression : IDENTIFIER

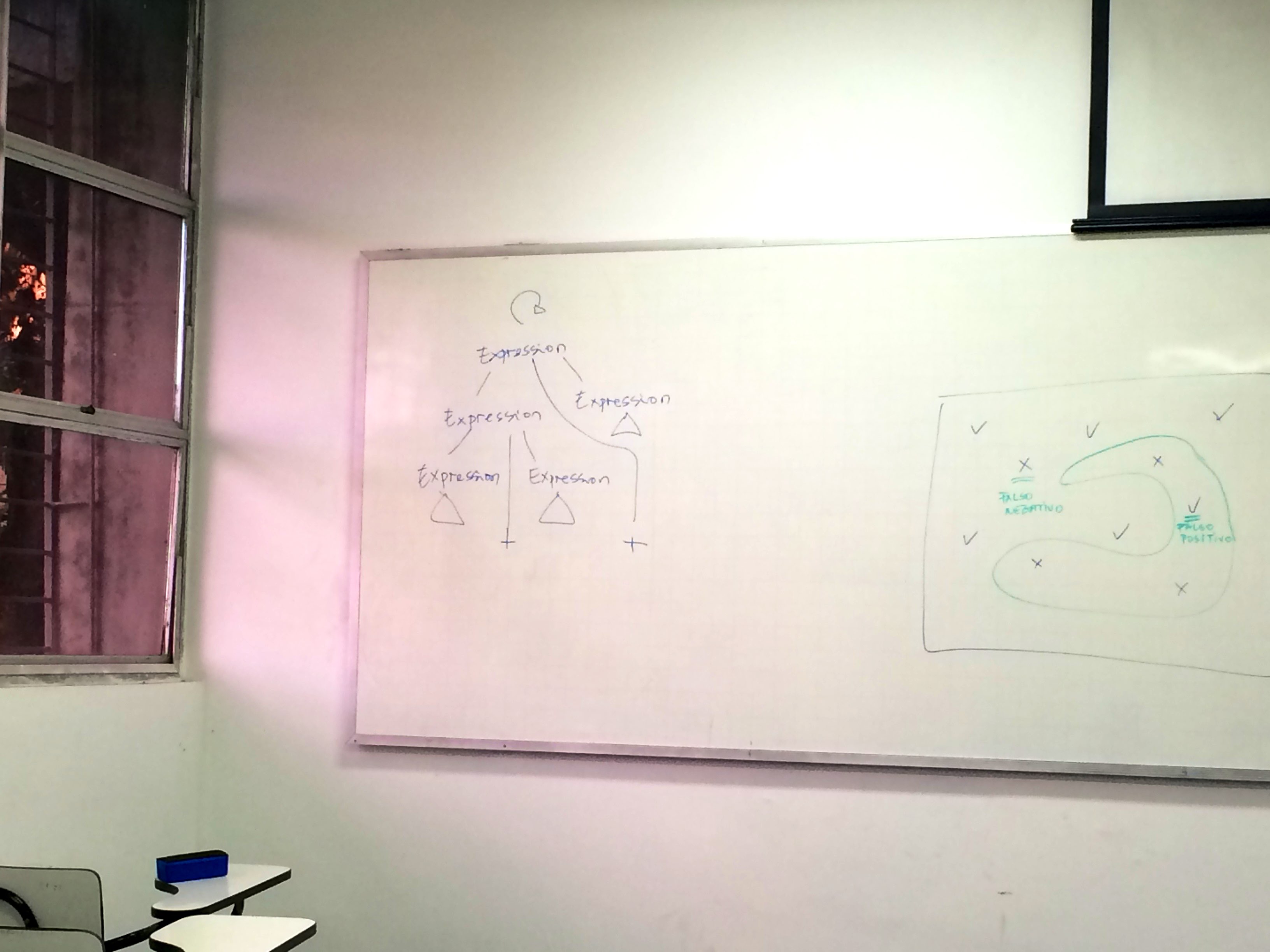
| NUMBER

| IDENTIFIER "+" Expression

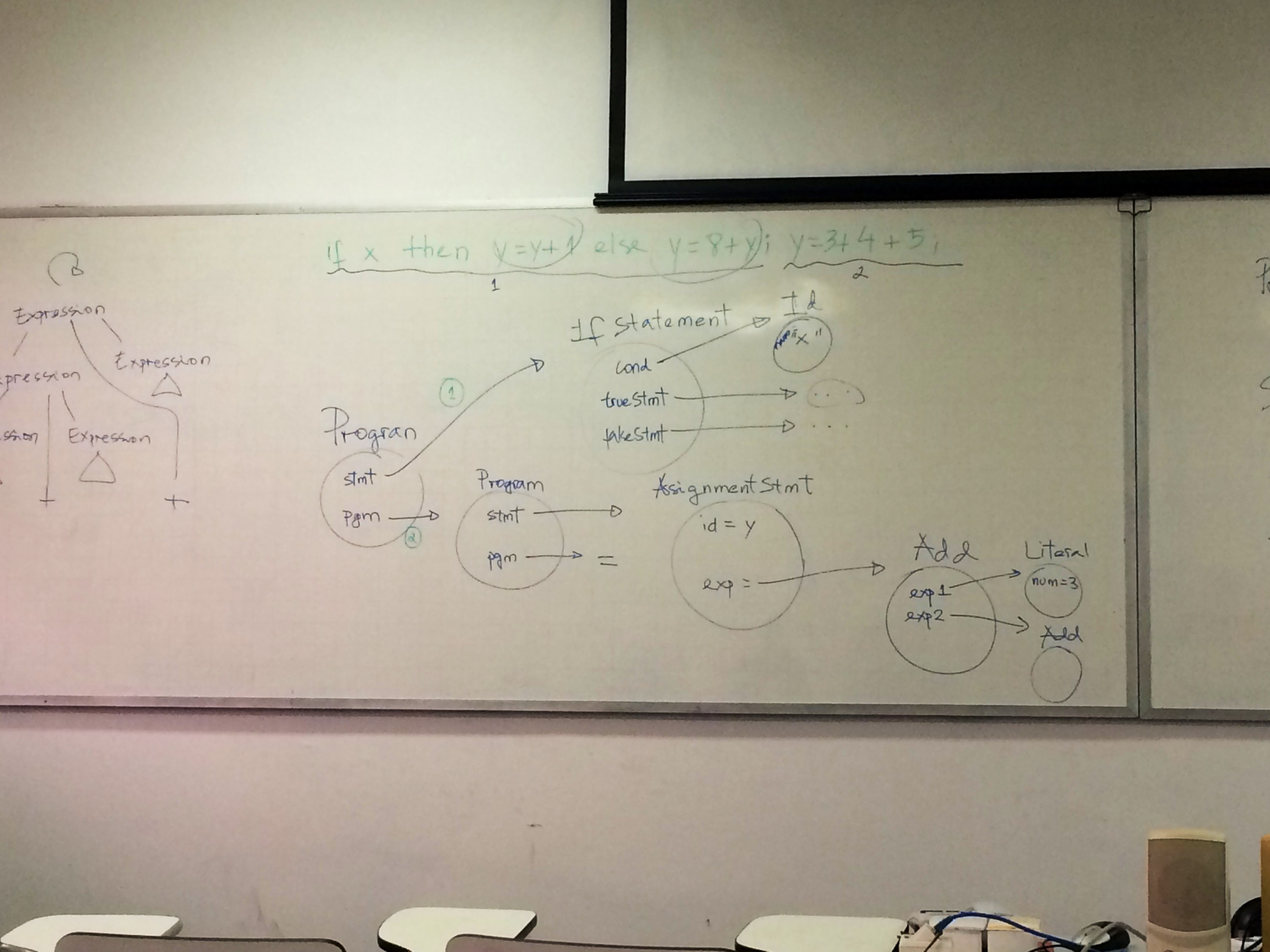
| NUMBER "+" Expression

;

A gramática original é ambígua, pois é possível formar, por exemplo, NUMBER + NUMBER + NUMBER derivando Expression à esquerda ou à direita. As versões acima resolveriam este problema.

Explicação de sala de aula (exemplo de derivação a esquerda que poderia ser feito com derivação à direita):

1. (2.0) Apresente uma árvore abstrata para o programa abaixo. Use a gramática acima, sem modificações, como referência. Os nomes que aparecem ao lado direito das produções correspondem aos nomes das estruturas de dados existentes para construir os nós da árvore. Faça referência a estas estruturas.

=> i**f** x **then** y = y + 1 **else** y = 8 + y **;** y = 3 + 4 + 5**;**

1. (2.0) Ilustre passo-a-passo como se faz top-down parsing e bottom-up parsing do programa acima utlizando a gramática apresentada na página anterior, sem modificações, como referência.

TOP-DOWN:

|  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- |
| if | x | then | y | = | y | + | 1 | else | y | = | 8 | + | y | ; | y | = | 3 | + | 4 | + | 5 | ; |

Program

|  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- |
| if | x | then | y | = | y | + | 1 | else | y | = | 8 | + | y | ; | y | = | 3 | + | 4 | + | 5 | ; |

Statement ; Program

|  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- |
| if | x | then | y | = | y | + | 1 | else | y | = | 8 | + | y | ; | y | = | 3 | + | 4 | + | 5 | ; |

"if" Expression "then" Statement "else" Statement ; Program

|  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- |
| if | x | then | y | = | y | + | 1 | else | y | = | 8 | + | y | ; | y | = | 3 | + | 4 | + | 5 | ; |

Expression "then" Statement "else" Statement ; Program

|  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- |
| if | x | then | y | = | y | + | 1 | else | y | = | 8 | + | y | ; | y | = | 3 | + | 4 | + | 5 | ; |

IDENTIFIER "then" Statement "else" Statement ; Program

|  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |
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| if | x | then | y | = | y | + | 1 | else | y | = | 8 | + | y | ; | y | = | 3 | + | 4 | + | 5 | ; |

Statement "else" Statement ; Program

|  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- |
| if | x | then | y | = | y | + | 1 | else | y | = | 8 | + | y | ; | y | = | 3 | + | 4 | + | 5 | ; |

IDENTIFIER = Expression "else" Statement ; Program

|  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- |
| if | x | then | y | = | y | + | 1 | else | y | = | 8 | + | y | ; | y | = | 3 | + | 4 | + | 5 | ; |

Expression "else" Statement ; Program

|  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- |
| if | x | then | y | = | y | + | 1 | else | y | = | 8 | + | y | ; | y | = | 3 | + | 4 | + | 5 | ; |

IDENTIFIER "else" Statement ; Program

|  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- |
| if | x | then | y | = | y | + | 1 | else | y | = | 8 | + | y | ; | y | = | 3 | + | 4 | + | 5 | ; |

"else" Statement ; Program (backtrack)

|  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- |
| if | x | then | y | = | y | + | 1 | else | y | = | 8 | + | y | ; | y | = | 3 | + | 4 | + | 5 | ; |

Expression + Expression "else" Statement ; Program

|  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- |
| if | x | then | y | = | y | + | 1 | else | y | = | 8 | + | y | ; | y | = | 3 | + | 4 | + | 5 | ; |

IDENTIFIER + Expression "else" Statement ; Program

|  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- |
| if | x | then | y | = | y | + | 1 | else | y | = | 8 | + | y | ; | y | = | 3 | + | 4 | + | 5 | ; |

Expression "else" Statement ; Program

|  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- |
| if | x | then | y | = | y | + | 1 | else | y | = | 8 | + | y | ; | y | = | 3 | + | 4 | + | 5 | ; |

NUMBER "else" Statement ; Program

|  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- |
| if | x | then | y | = | y | + | 1 | else | y | = | 8 | + | y | ; | y | = | 3 | + | 4 | + | 5 | ; |

Statement ; Program

|  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- |
| if | x | then | y | = | y | + | 1 | else | y | = | 8 | + | y | ; | y | = | 3 | + | 4 | + | 5 | ; |

IDENTIFIER = Expression ; Program

|  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- |
| if | x | then | y | = | y | + | 1 | else | y | = | 8 | + | y | ; | y | = | 3 | + | 4 | + | 5 | ; |

Expression ; Program

|  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- |
| if | x | then | y | = | y | + | 1 | else | y | = | 8 | + | y | ; | y | = | 3 | + | 4 | + | 5 | ; |

NUMBER ; Program

|  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- |
| if | x | then | y | = | y | + | 1 | else | y | = | 8 | + | y | ; | y | = | 3 | + | 4 | + | 5 | ; |

; Program (backtrack)

|  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- |
| if | x | then | y | = | y | + | 1 | else | y | = | 8 | + | y | ; | y | = | 3 | + | 4 | + | 5 | ; |

Expression + Expression ; Program

|  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- |
| if | x | then | y | = | y | + | 1 | else | y | = | 8 | + | y | ; | y | = | 3 | + | 4 | + | 5 | ; |

NUMBER + Expression ; Program

|  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- |
| if | x | then | y | = | y | + | 1 | else | y | = | 8 | + | y | ; | y | = | 3 | + | 4 | + | 5 | ; |

Expression ; Program

|  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- |
| if | x | then | y | = | y | + | 1 | else | y | = | 8 | + | y | ; | y | = | 3 | + | 4 | + | 5 | ; |

IDENTIFIER ; Program

|  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- |
| if | x | then | y | = | y | + | 1 | else | y | = | 8 | + | y | ; | y | = | 3 | + | 4 | + | 5 | ; |

Program

|  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- |
| if | x | then | y | = | y | + | 1 | else | y | = | 8 | + | y | ; | y | = | 3 | + | 4 | + | 5 | ; |

Statement ; Program

|  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- |
| if | x | then | y | = | y | + | 1 | else | y | = | 8 | + | y | ; | y | = | 3 | + | 4 | + | 5 | ; |

IDENTIFIER = Expression ; Program

|  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- |
| if | x | then | y | = | y | + | 1 | else | y | = | 8 | + | y | ; | y | = | 3 | + | 4 | + | 5 | ; |

Expression ; Program

|  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- |
| if | x | then | y | = | y | + | 1 | else | y | = | 8 | + | y | ; | y | = | 3 | + | 4 | + | 5 | ; |

NUMBER ; Program

|  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- |
| if | x | then | y | = | y | + | 1 | else | y | = | 8 | + | y | ; | y | = | 3 | + | 4 | + | 5 | ; |

; Program (backtrack)

|  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- |
| if | x | then | y | = | y | + | 1 | else | y | = | 8 | + | y | ; | y | = | 3 | + | 4 | + | 5 | ; |

Expression + Expression ; Program

|  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- |
| if | x | then | y | = | y | + | 1 | else | y | = | 8 | + | y | ; | y | = | 3 | + | 4 | + | 5 | ; |

NUMBER + Expression ; Program

|  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- |
| if | x | then | y | = | y | + | 1 | else | y | = | 8 | + | y | ; | y | = | 3 | + | 4 | + | 5 | ; |

Expression ; Program

|  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- |
| if | x | then | y | = | y | + | 1 | else | y | = | 8 | + | y | ; | y | = | 3 | + | 4 | + | 5 | ; |

NUMBER ; Program

|  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- |
| if | x | then | y | = | y | + | 1 | else | y | = | 8 | + | y | ; | y | = | 3 | + | 4 | + | 5 | ; |

; Program (backtrack)

|  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- |
| if | x | then | y | = | y | + | 1 | else | y | = | 8 | + | y | ; | y | = | 3 | + | 4 | + | 5 | ; |

Expression + Expression ; Program

|  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- |
| if | x | then | y | = | y | + | 1 | else | y | = | 8 | + | y | ; | y | = | 3 | + | 4 | + | 5 | ; |

NUMBER + Expression ; Program

|  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- |
| if | x | then | y | = | y | + | 1 | else | y | = | 8 | + | y | ; | y | = | 3 | + | 4 | + | 5 | ; |

Expression ; Program

|  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- |
| if | x | then | y | = | y | + | 1 | else | y | = | 8 | + | y | ; | y | = | 3 | + | 4 | + | 5 | ; |

NUMBER ; Program

|  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- |
| if | x | then | y | = | y | + | 1 | else | y | = | 8 | + | y | ; | y | = | 3 | + | 4 | + | 5 | ; |

Program

|  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- |
| if | x | then | y | = | y | + | 1 | else | y | = | 8 | + | y | ; | y | = | 3 | + | 4 | + | 5 | ; |

/\* produção vazia /

BOTTOM-UP:

|  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- |
| if | x | then | y | = | y | + | 1 | else | y | = | 8 | + | y | ; | y | = | 3 | + | 4 | + | 5 | ; |

if IDENTIFIER

|  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- |
| if | x | then | y | = | y | + | 1 | else | y | = | 8 | + | y | ; | y | = | 3 | + | 4 | + | 5 | ; |

if Expression then

|  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- |
| if | x | then | y | = | y | + | 1 | else | y | = | 8 | + | y | ; | y | = | 3 | + | 4 | + | 5 | ; |

if Expression then IDENTIFIER

|  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- |
| if | x | then | y | = | y | + | 1 | else | y | = | 8 | + | y | ; | y | = | 3 | + | 4 | + | 5 | ; |

if Expression then IDENTIFIER = IDENTIFIER +

|  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- |
| if | x | then | y | = | y | + | 1 | else | y | = | 8 | + | y | ; | y | = | 3 | + | 4 | + | 5 | ; |

if Expression then IDENTIFIER = IDENTIFIER + NUMBER

|  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- |
| if | x | then | y | = | y | + | 1 | else | y | = | 8 | + | y | ; | y | = | 3 | + | 4 | + | 5 | ; |

if Expression then IDENTIFIER = Expression + Expression

|  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- |
| if | x | then | y | = | y | + | 1 | else | y | = | 8 | + | y | ; | y | = | 3 | + | 4 | + | 5 | ; |

if Expression then IDENTIFIER = Expression

|  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- |
| if | x | then | y | = | y | + | 1 | else | y | = | 8 | + | y | ; | y | = | 3 | + | 4 | + | 5 | ; |

if Expression then Statement else

|  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- |
| if | x | then | y | = | y | + | 1 | else | y | = | 8 | + | y | ; | y | = | 3 | + | 4 | + | 5 | ; |

if Expression then Statement else IDENTIFIER =

|  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- |
| if | x | then | y | = | y | + | 1 | else | y | = | 8 | + | y | ; | y | = | 3 | + | 4 | + | 5 | ; |

if Expression then Statement else IDENTIFIER = NUMBER +

|  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- |
| if | x | then | y | = | y | + | 1 | else | y | = | 8 | + | y | ; | y | = | 3 | + | 4 | + | 5 | ; |

if Expression then Statement else IDENTIFIER = NUMBER + IDENTIFIER

|  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- |
| if | x | then | y | = | y | + | 1 | else | y | = | 8 | + | y | ; | y | = | 3 | + | 4 | + | 5 | ; |

if Expression then Statement else IDENTIFIER = Expression + Expression

|  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- |
| if | x | then | y | = | y | + | 1 | else | y | = | 8 | + | y | ; | y | = | 3 | + | 4 | + | 5 | ; |

if Expression then Statement else IDENTIFIER = Expression

|  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- |
| if | x | then | y | = | y | + | 1 | else | y | = | 8 | + | y | ; | y | = | 3 | + | 4 | + | 5 | ; |

Statement ;

|  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- |
| if | x | then | y | = | y | + | 1 | else | y | = | 8 | + | y | ; | y | = | 3 | + | 4 | + | 5 | ; |

Statement ; IDENTIFIER =

|  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- |
| if | x | then | y | = | y | + | 1 | else | y | = | 8 | + | y | ; | y | = | 3 | + | 4 | + | 5 | ; |

Statement ; IDENTIFIER = NUMBER +

|  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- |
| if | x | then | y | = | y | + | 1 | else | y | = | 8 | + | y | ; | y | = | 3 | + | 4 | + | 5 | ; |

Statement ; IDENTIFIER = NUMBER + NUMBER

|  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- |
| if | x | then | y | = | y | + | 1 | else | y | = | 8 | + | y | ; | y | = | 3 | + | 4 | + | 5 | ; |

Statement ; IDENTIFIER = Expression + Expression

|  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- |
| if | x | then | y | = | y | + | 1 | else | y | = | 8 | + | y | ; | y | = | 3 | + | 4 | + | 5 | ; |

Statement ; IDENTIFIER = Expression

|  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- |
| if | x | then | y | = | y | + | 1 | else | y | = | 8 | + | y | ; | y | = | 3 | + | 4 | + | 5 | ; |

Statement ; IDENTIFIER = Expression + NUMBER

|  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- |
| if | x | then | y | = | y | + | 1 | else | y | = | 8 | + | y | ; | y | = | 3 | + | 4 | + | 5 | ; |

Statement ; IDENTIFIER = Expression + Expression

|  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- |
| if | x | then | y | = | y | + | 1 | else | y | = | 8 | + | y | ; | y | = | 3 | + | 4 | + | 5 | ; |

Statement ; IDENTIFIER = Expression

|  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- |
| if | x | then | y | = | y | + | 1 | else | y | = | 8 | + | y | ; | y | = | 3 | + | 4 | + | 5 | ; |

Statement ; Statement

|  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- |
| if | x | then | y | = | y | + | 1 | else | y | = | 8 | + | y | ; | y | = | 3 | + | 4 | + | 5 | ; |

Statement ; Statement ; /\* produção vazia \*/

|  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- |
| if | x | then | y | = | y | + | 1 | else | y | = | 8 | + | y | ; | y | = | 3 | + | 4 | + | 5 | ; |

Statement ; Program

|  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- |
| if | x | then | y | = | y | + | 1 | else | y | = | 8 | + | y | ; | y | = | 3 | + | 4 | + | 5 | ; |

Program