Franklin's 13 virtues and Puritan ethics

Temperance
Silence
Order
Resolution

(5) Frugality: Make no expense but to do good to others or yourself; i.e., waste nothing.

节俭：不要做无益的花销，杜绝不必要的浪费。

静以修身，俭以养德

(6)Industry: Lose no time; be always employed in something useful; cut off all unnecessary actions.

勤勉：不浪费时间，时时刻刻都要用于正经事，戒除一切不必要的行动。

Lost wealth may be replaced by industry, lost knowledge by study, lost health by temperance or medicine, but lost time is gone forever.

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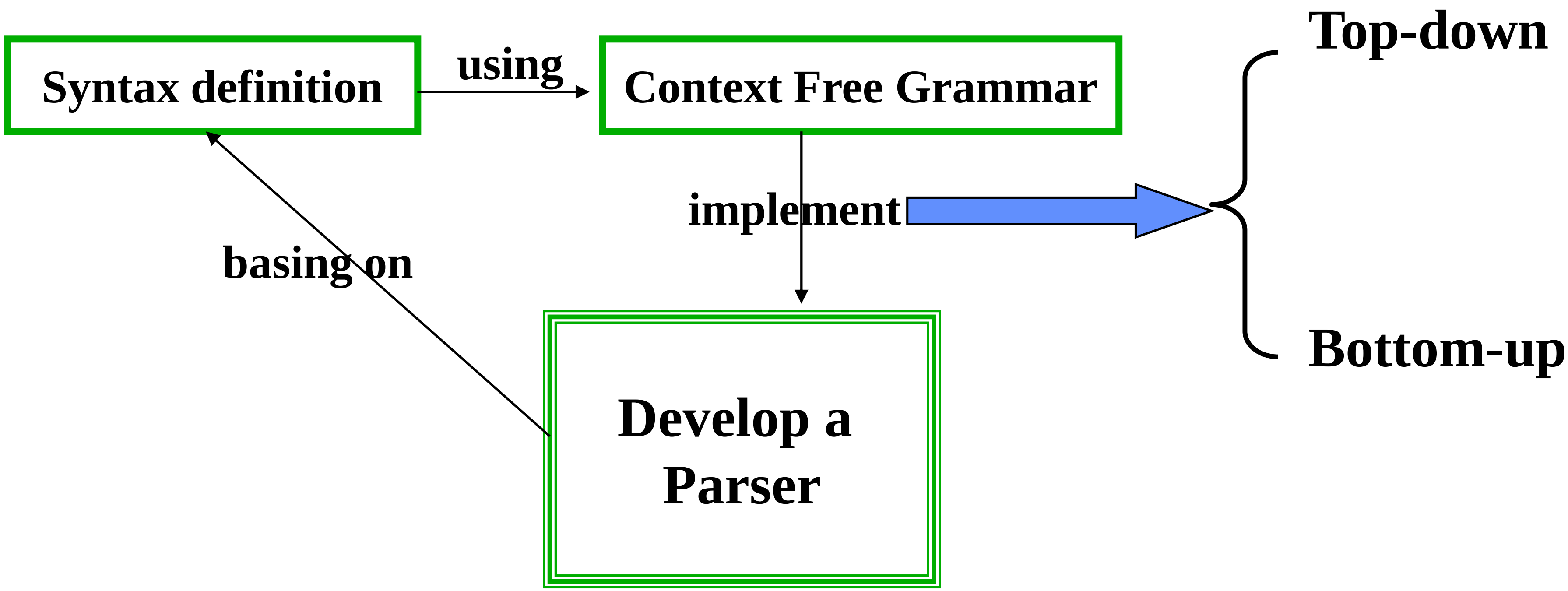
Compiling and Running of Program

Dr. Zheng Xiaojuan
Professor

October. 2019

Knowledge Relation Graph



§ 3 Context Free Grammar & Parsing

3.1 The Parsing Process （语法分析过程）

3.2 Context-free Grammars （上下文无关文法）

3.3 Parse Trees and Abstract Syntax Tree （语法分析树和抽象语法树）

3.4 Ambiguous （二义性）

3.5 Syntax of Sample Language （简单语言的语法）

§ 4 Top-down Parsing

4.1 Overview of Top-down Parsing

4.2 Three Important Sets

4.3 Left Recursion Removal & Left Factoring

4.4 Recursive-Descent Parsing

4.5 LL(1) Parsing

4.1 Overview of Top-down Parsing

- **Problem:**
  - **Given CFG definition of the Syntax;**
  - **Check whether a program is of well defined structure;**
  - **Generate parse tree of the program;**
- **Main Idea**
  - **Read sequence of tokens (source program);**
  - **Start from the start symbol;**
  - **Try to find a proper sequence of derivations, resulting in the sequence of token of the source program;**

Example

P:

(1) $Z \rightarrow aBd$
(2) $B \rightarrow d$
(3) $B \rightarrow c$
(4) $B \rightarrow bB$

a	b	c	d

句型	输入	动作
Z	abcd	Derive (1) （指针所指）
aBd	abcd	Match （指针后移）
Bd	bcd	Derive(4)
bBd	bcd	Match
Bd	cd	Derive(3)
cd	cd	Match
d	d	Match
		Succeed

4.1 Overview of Top-down Parsing

- **Key problem:（derivation、match）**
  - **According to rest token sequence and the first non-terminal symbol, how to select a right production to make next derivation?**
- **Look ahead how many tokens?**
  - **Current token (look ahead one token)**
- **Calculate *<u>Predict set</u>* for a production $A \rightarrow \gamma$**
  - **$\{a \mid S \Rightarrow^{+} \alpha A \beta \Rightarrow \alpha \gamma \beta \Rightarrow^{+} \alpha a \beta'\}$, where $\alpha \in V_T^*$, S is start symbol.**

How to calculate the predict set for each production?

4.2 Three Important Sets

- ***First Set(first集)*** **for a string α with non-terminal and terminal symbols;**
  - **First(α)(non-terminal的*first集*）**
- ***Follow Set(follow集)*** **for a non-terminal symbol A;**
  - **Follow(A)**
- ***Predict Set(预测集)*** **for a production;**
  - **Predict(A→ α)**

First Set (first集)

- **Definition:**
  - **$First(\alpha) = \{a \mid \alpha \Rightarrow^* a\beta,\ a \in V_T\}$,**
  - **if $\alpha \Rightarrow^* \varepsilon$ then $First(\alpha) = First(\alpha) \cup \{\varepsilon\}$**

- **How to calculate First(α)?** （α是产生式右部）
  - **$\alpha = \varepsilon$,** **$First(\alpha) = \{\varepsilon\}$**
  - **$\alpha = a,\ a \in V_T$,** **$First(\alpha) = \{a\}$**
  - **$\alpha = A\beta$，$A \in V_N$,** **$First(\alpha) = First(A)$**
  - **$\alpha = A_1 A_2 \ldots\ldots A_{i-1} A_i \ldots\ldots A_n$，$A_1 \Rightarrow^* \varepsilon$**

$\alpha = A_1 A_2 \ldots\ldots A_{i-1} A_i \ldots\ldots A_n, \quad A_1 \Rightarrow^* \varepsilon$

For each symbol A, calculate First(A)

- $S_\varepsilon = \{A \mid A \Rightarrow^* \varepsilon , A \in V_N\}$
- $V_N=\{A_1, \ldots, A_n\}$, calculate First(A_i)

(1)初始化, First(A_i) ={};

(2)for i =1 to n 对于A_i的每个产生式,

- if $A_i \rightarrow \varepsilon$, First($A_i$) = First($A_i$) $\cup$ {ε};
- if $A_i \rightarrow Y_1 \ldots Y_m$, $\{Y_1 ,\ldots ,Y_m\} \subseteq S_\varepsilon$,
  First(A_i) = First(A_i) $\cup$ First(Y_1) $\cup$ ….. $\cup$ First(Y_m)
- if $A_i \rightarrow Y_1 \ldots Y_m$, $\{Y_1 ,\ldots ,Y_{j-1}\} \subseteq S_\varepsilon$, $Y_j \notin S_\varepsilon$
  First(A_i) = {First(A_i) $\cup$ {First(Y_1) $\cup$ ….. $\cup$ First(Y_{j-1})-{ε}} $\cup$ First(Y_j)

(3) Repeat (2) until 每个First(A_i)没有变化(收敛).

Example

$S\varepsilon = \{E', T'\}$

P:

(1) $E \rightarrow TE'$

(2) $E' \rightarrow + TE'$

(3) $E' \rightarrow \varepsilon$

(4) $T \rightarrow FT'$

(5) $T' \rightarrow * F T'$

(6) $T' \rightarrow \varepsilon$

(7) $F \rightarrow (E)$

(8) $F \rightarrow i$

(9) $F \rightarrow n$

E	{i, n , (}
E'	{ + , ε }
T	{ i, n , (}
T'	{ *, ε }
F	{ i, n , (}

Example

P:

(1) E → TE’
(2) E’ → + TE’
(3) E’ → ε
(4) T → FT’
(5) T’ → * F T’
(6) T’ → ε
(7) F → (E)
(8) F → i
(9) F → n

E	{i, n , (}
E’	{ + , ε }
T	{ i, n , (}
T’	{ *, ε }
F	{ i, n , (}

First(E’T’E) =

First(T’E’) =

4.2 Three Important Sets

- ***First Set(first集)*** **for a string α with non-terminal and terminal symbols;**
  - **First(α)**
- ***Follow Set(follow集)*** **for a non-terminal symbol A;**
  - **Follow(A)**
- ***Predict Set(预测集)*** **for a production;**
  - **Predict(A→ α)**

Follow Set (follow集)

- **Definition:**
  - **Follow(A) = $\{a \mid S \Rightarrow^{+} \ldots Aa \ldots,\ a \in V_T\}$,**
  - **if $S \Rightarrow^{+} \ldots A$, then Follow(A)= Follow(A) $\cup$ {#}**
  - **# represents the end of the string**

(0) Z → cAb

(1) A →a的First(A)？

(2) A → ε的First(A)？

Z → cAb ⇒ cab?通过求产生式（1）First(A) =a确定选择产生式（1）

Z → cAb ⇒ cb? 通过求产生式（2） Follow (A) =b确定选择产生式（2）

Follow Set (follow集)

- **How to calculate Follow(A), $A \in V_N$**

  (1)初始化, $\forall A \in V_N$, Follow(A) = { }

  (2)Follow(S) = {#}

  (3)对于每个产生式$A \to \alpha$

  - **If there is no non-terminal symbol in α, skip;**
  - **If $\alpha = \beta B \gamma$, $B \in V_N$, Follow(B) = Follow(B) $\cup$ (First(γ)-{ε})**
  - **If $\varepsilon \in$ First(γ), Follow(B) = Follow(B) $\cup$ Follow(A)**
  - **If $\alpha = \beta B$, Follow(B) = Follow(B) $\cup$ Follow(A)**

  (4) Repeat (3) until all follow sets do not change any more;

$Z \Rightarrow cAb$

$\Rightarrow c\,\beta B b$

$A \to \beta B$

Example

P:

(1) E → TE’

(2) E’ → + TE’

(3) E’ → ε

(4) T → FT’

(5) T’ → * F T’

(6) T’ → ε

(7) F → (E)

(8) F → i

(9) F → n

E	{i, n , (}
E’	{ + , ε }
T	{ i, n , (}
T’	{ *, ε }
F	{ i, n , (}

E	{#,)}
E’	{#,)}
T	{+,), #}
T’	{+,), #}
F	{*, +,), #}

4.2 Three Important Sets

- ***First Set(first集)*** **for a string α with non-terminal and terminal symbols;**
  - **First(α)**
- ***Follow Set(follow集)*** **for a non-terminal symbol A;**
  - **Follow(A)**
- ***Predict Set(预测集)*** **for a production;**
  - **Predict(A→ α)**

Predict Set (predict集)

- **Definition:**
  - **Predict(A → α) = first(α), if ε ∉ first(α);**
  - **Predict(A → α) = (first(α)- ε) ∪ follow(A),**
    if ε ∈ first(α);
  - **Predict(A → ε) = follow(A),**

Example

P:

(1) E → TE' → First(TE')={i, n,(}

(2) E' → + TE' → First(+TE')={+}

(3) E' → ε → Follow(E')={#,)}

(4) T → FT' → First(FT')={i,n,(}

(5) T' →* F T' → First(*FT')={*}

(6) T' → ε → Follow(T')={),+, # }

(7) F → (E) → First((E))={ (}

(8) F → i → First(i)={i}

(9) F → n → First(n)={n}

first集

E	{i, n , (}
E'	{ + , ε }
T	{ i, n , (}
T'	{ *, ε }
F	{ i, n , (}

follow集

E	{#,)}
E'	{#,)}
T	{+,), #}
T'	{+,), #}
F	{*, +,), #}

Top-down parsing

- **Precondition for Top-down parsing (look ahead one symbol) 自顶向下语法分析方法的前提条件**
  - **$G = (V_T, V_N, S, P)$**
  - **For any $A \in V_N$,**
  - **For any two productions of A,**
  - **$Predict(A \to \alpha 1) \cap Predict(A \to \alpha 2) = \Phi$**

  (同一个非终极符的任意两个产生式的predict集合互不相交)
- **这个条件保证:针对当前的符号和当前的非终极符,可以选择唯一的产生式来进行推导;**

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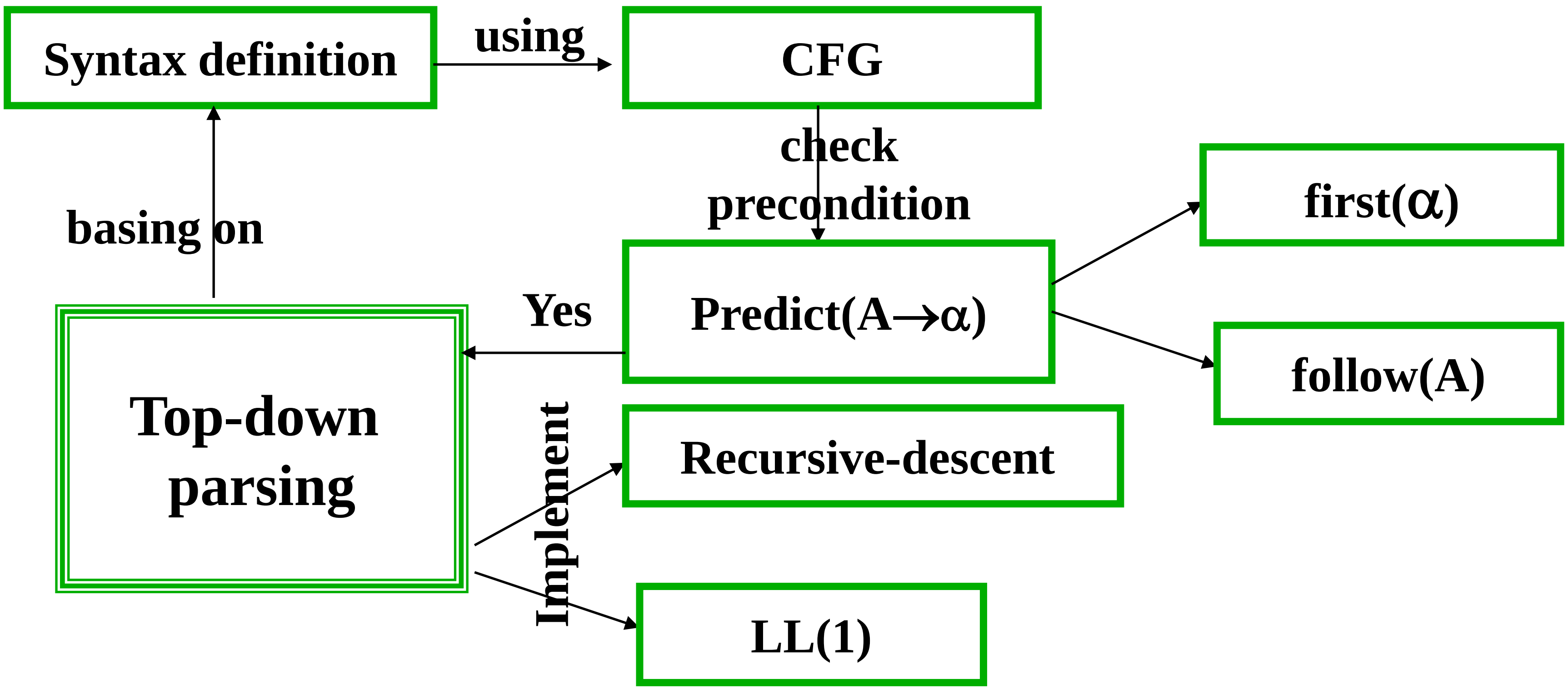
Example

P:	
(1) Z → aBd	{a}
(2) B → d	{d}
(3) B → c	{c}
(4) B → bB	{b}

a	b	c	d

句型	输入	动作
Z	abcd	Derive (1)
aBd	abcd	Match
Bd	bcd	Derive(4)
bBd	bcd	Match
Bd	cd	Derive(3)
cd	cd	Match
d	d	Match
		Succeed

Knowledge Relation Graph



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4.3 Left Recursion Removal & Left Factoring

- 消除左递归
  - 直接左递归
  - 间接左递归
- 消除公共前缀
  - 提取公共前缀

4.4 Recursive-Descent Parsing

- **Main Idea:**
  - **For each non-terminal symbol, generate one parsing sub-routine(语法分析子过程）according to its productions;**
- **递归下降法:**
  - **针对满足*分析条件*的CFG;**
  - **“递归”:由于产生式的递归导致分析子程序的递归;**
  - **“下降”：自项向下分析;**
- **Disadvantages:**
  - **Restriction on CFG is too strict;**
  - **inefficient because of too many function calls;**

4.4 Recursive-Descent Parsing

- **The goal of parsing**
  - ***Check* whether the input string belongs to the language of CFG;**
- **Two actions**
  - **match(a): to check current symbol, if match, read next symbol;**
  - **Derivation: select the production**

Example

P:	
(1) Z → aBd	{a}
(2) B → d	{d}
(3) B → c	{c}
(4) B → bB	{b}

a	b	c	d

```
Z ( )
{
if token = a
 {match(a);
  B( );
  match(d);
  }
else error( );
}
```

```
B ( )
{
 case token of
  d: match(d);break;
  c: match(c); break;
  b:{ match(b);
        B( ); break;}
  other: error( );
}
```

```
main( ){ read(token); Z( )}
```

General Process

- **$G = (V_T, V_N, S, P)$**
- **Predefined function:**

  void match(a: V_T)
- **Global variable:**

  token: V_T
- **Input string: str**

- **For each $A \in V_N$,**
- **$A \rightarrow \alpha_1 | \ldots\ldots | \alpha_n$**

```
A( )
{ case token of
    Predict(A → α1):  SubR(α1)  ; break;
    ……
    Predict(A → αn): SubR(αn) ; break;
    other: error;
}
```

General Process

```
void match(a: V_T)
{
 if token == a
     token = readNext(str);
  else error();
}
```

SubR(α):

$\alpha = X_1 X_2 \ldots\ldots X_n$

If $X_i \in V_T$, match(X_i)
If $X_i \in V_N$, X_i();

SubR(α): $\alpha = \varepsilon$	{ }

Some Notes

- **Not real parsing program, but algorithm;**
- **More detailed issues need to be considered**
  - **Dealing with errors**
  - **Building parse tree**

How to deal with these issues?

Building Parse Tree

- **Data structure**
  - **ParseTree**

符号	儿子个数	儿子指针 →

- **Operations**
  - **ParseTree BuildRoot(symbol: V_T);**
  - **ParseTree BuildOneNode(symbol: $V_T \cup V_N$)**
  - **AddOneSon(father:*ParseTree, son:*ParseTree)**
  - **SetNum(Node:*ParseTree, n:int)**

Example

```
   *ParseTree        Z ( )
{     if token = a {
      T = BuildRoot(Z);    SetNum(T, 3);
      match(a);   A = BuildOneSon(a); AddOneSon(T, A);

       BB= B( );    AddOneSon(T, BB);

      match(d);  D = BuildOneSon(d); AddOneSon(T, D);
      return T;
      }  else  {error(); return nil;}
}
```

Example

```
 B ( )
{
 case token of
    d: match(d);break;
    c: match(c); break;
    b:{ match(b);
           B( ); break;}
    other: error();
}
```

You can do it yourself!

Assignment

- $G = \{V_T, V_N, S, P\}$
- $V_T = \{-\ ,\ (,\ ),\ id\}$
- $V_N = \{E, ET, V, VT\}$
- $S = E$
- $P = \{\ E \rightarrow -E$

$$E \rightarrow (E)$$
$$E \rightarrow V\ \ ET$$
$$ET \rightarrow -E$$
$$ET \rightarrow \varepsilon$$
$$V \rightarrow id\ VT$$
$$VT \rightarrow (E)$$
$$VT \rightarrow \varepsilon\quad \}$$

Write recursive-descent parsing program for G.

Assignment

- **According to the CFG of C0, write down recursive-desce parsing program.**

  (根据C0语言的上下文无关文法的定义，写出递归下降法程序.）

  - **(1) calculate predict sets for each production;**
  - **(2) check whether the grammar meets the precondition;**
  - **(3) if not, rewrite grammar;**
  - **(4) write function for each non-terminal symbol;**

Build parse tree!

§ 4 Top-down Parsing

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4.4 Recursive-Descent Parsing

4.5 LL(1) Parsing

4.5 LL(1) Parsing

- **Main idea of LL(1) Parsing Method**
- **LL(1) Grammar (LL(1)文法)**
- **LL(1) Parsing Table (LL(1)分析表)**
- **LL(1) Parsing Engine (LL(1)分析驱动程序)**
- **LL(1) Parsing Process (LL(1)分析过程)**
- **LL(1) Parser Generator – LLGen、JavaCC (LL(1)分析程序的自动生成器)**

Main idea of LL(1) Parsing Method

- **LL(1) Parsing**
  - **Left-to-right parsing, Left-most derivation, 1-symbol look ahead ;**
  - **Requires the same precondition(和递归下降法要求相同的前提条件)**
    - **$G = (V_T, V_N, S, P)$**
    - **For any $A \in V_N$,**
    - **For any two productions of A,**
    - **$Predict(A \rightarrow \alpha 1) \cap Predict(A \rightarrow \alpha 2) = \Phi$**

Main idea of LL(1) Parsing Method

- **LL(1) Parsing**
  - **LL(1) parsing table to record predict sets for each production; (LL(1)分析表)**
  - **A general engine(一个通用的驱动程序)**

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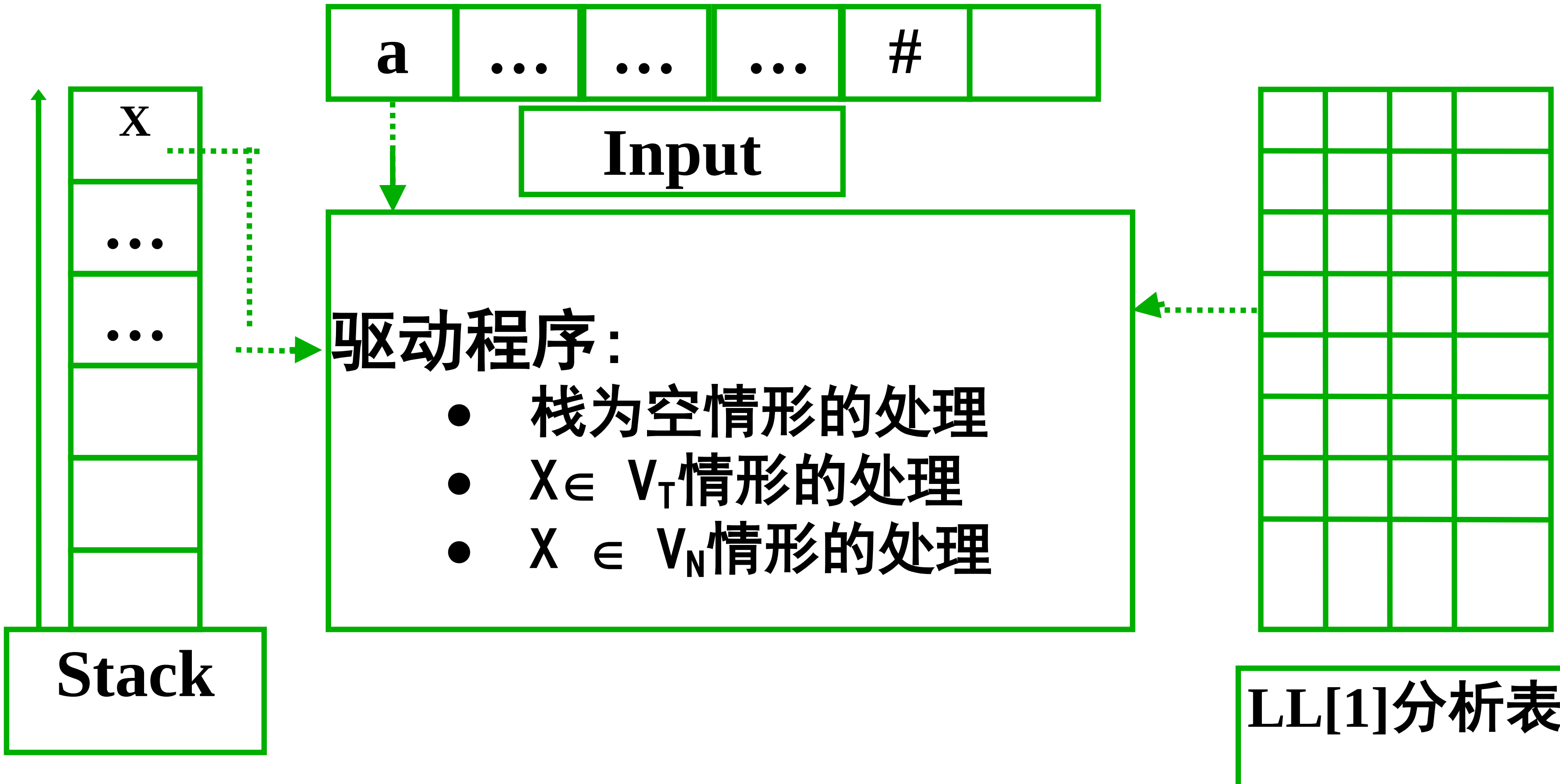
LL(1) Parsing Mechanism



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- **LL(1) Parser Generator – LLGen、JavaCC (LL(1)分析程序的自动生成器)**

LL(1) Grammar

- **If a CFG *G* meets the precondition below, we will call *G* is a LL(1) Grammar;**

$G = (V_T, V_N, S, P)$
For any $A \in V_N$,
For any two productions of A,
$Predict(A \to \alpha_1) \cap Predict(A \to \alpha_2) = \Phi$

4.5 LL(1) Parsing

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- **LL(1) Parser Generator – LLGen (LL(1)分析程序的自动生成器)**

LL(1) Parsing Table (LL(1)分析表)

- **The purpose of LL(1) Parsing Table**
  - **According to <current non-terminal symbol, current input symbol>, decide that which production of current non-terminal symbol can be used to derive;**
  - **根据当前的非终极符和当前的输入符（输入流）决定用哪一个产生式来进行推导;**
- **If current non-terminal symbol is X, current input symbol is a, we can use $X\rightarrow\alpha$ if and only if $a\in$predict($X\rightarrow\alpha$);**

LL(1) Parsing Table (LL(1)分析表)

- **How to build LL(1) Parsing Table for a LL(1) Grammar?**
  - **For a LL(1) Grammar G = (V_T, V_N, S, P)**
  - **$V_T = \{a_1, \ldots, a_n\}$**
  - **$V_N = \{A_1, \ldots, A_n\}$**
  - **$LL(A_i, a_i) = [A_i \rightarrow \alpha]$, if $a_i \in predict(A_i \rightarrow \alpha)$**
  - **$LL(A_i, a_i)$ = error, if a_i not belong to the predict set of any production of A_i**

	a_1	…	a_n	#
A_1				
…	….	….	…	
A_n				

Example

P:

(1) Z → aBd
(2) B → d
(3) B → c
(4) B → bB

产生式	Predict集
(1)	{a}
(2)	{d}
(3)	{c}
(4)	{b}

	a	b	c	d	#
Z	(1)				
B		(4)	(3)	(2)	

Example

(1) E $\rightarrow$ TE’	{ i, n, (}
(2) E’ $\rightarrow$ + TE’	{+}
(3) E’ $\rightarrow$ ε	{#,)}
(4) T $\rightarrow$ FT’	{i,n,(}
(5) T’ $\rightarrow$ * F T’	{*}
(6) T’ $\rightarrow$ ε	{),+, # }
(7) F $\rightarrow$ (E)	{ (}
(8) F $\rightarrow$ i	{i}
(9) F $\rightarrow$ n	{n}

	+	*	(	)	i	n	#
E			(1)		(1)	(1)	
E’	(2)			(3)			(3)
T			(4)		(4)	(4)	
T’	(6)	(5)		(6)			(6)
F			(7)		(8)	(9)	

4.5 LL(1) Parsing

- **Main idea of LL(1) Parsing Method**
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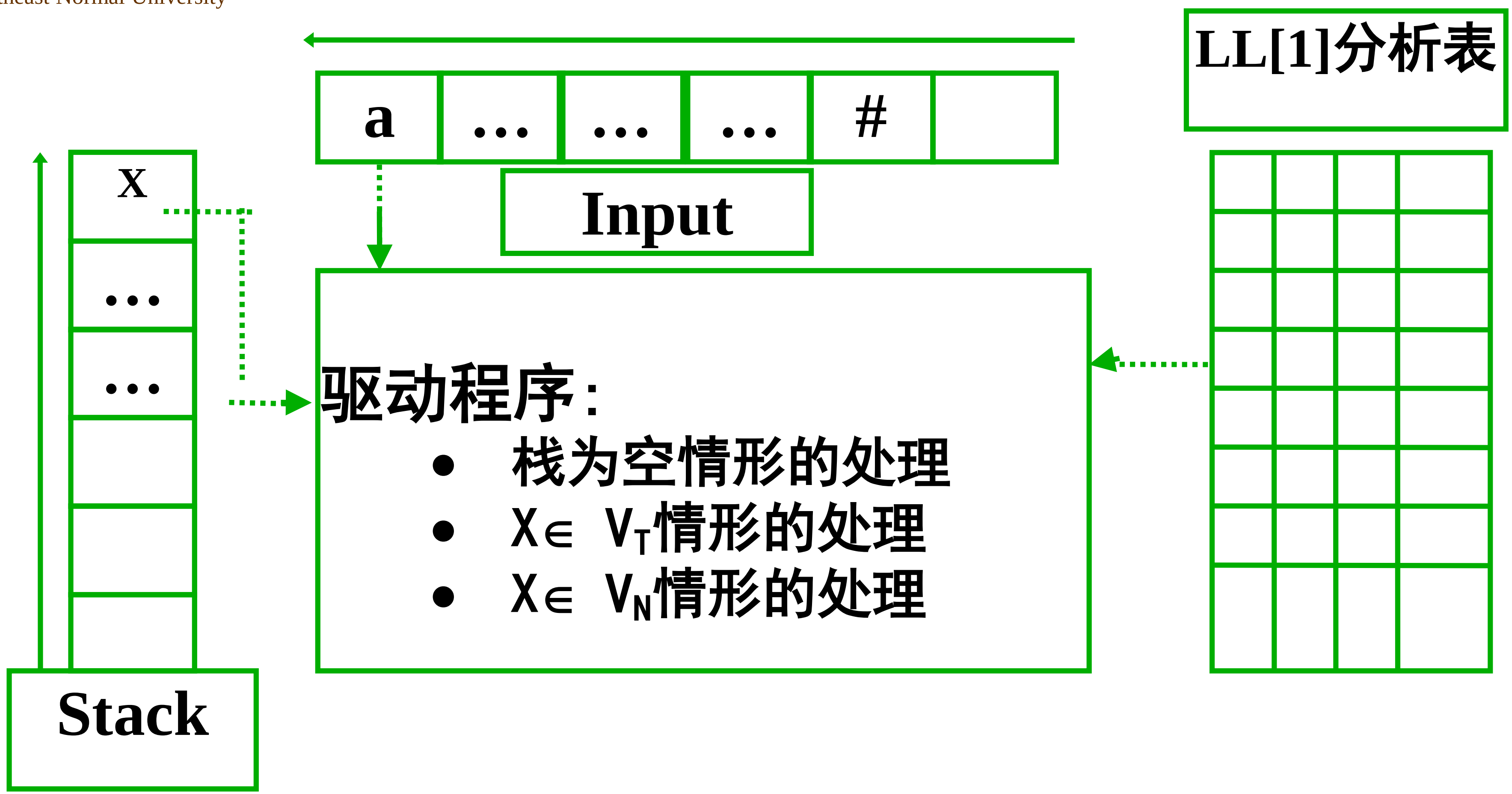
LL(1) Parsing Engine 分析驱动程序



LL(1) Parsing Engine

- **Configuration(格局): <stack, input>**
- **可能的情形**
  - **栈为空情形的处理< , a> : succeed, if a=#, else error;**
  - **X$\in V_T$情形的处理: <a, a>, match; else error;**
  - **X $\in V_N$情形的处理: <X, a>, derive if there is a production X$\to\alpha$ such that a$\in$predict(X$\to\alpha$), else error;**

LL(1) Parsing Engine

[1] 初始化： Stack := [ ]；Push(S)；

[2] 读下一个输入符： Read(a)；

[3] 若当前格局是(, #)，则成功结束；否则转下；

[4] 设当前格局为（..... X, a.....)，则

- 若 $X\in V_T$ & X= a，则 { Pop(1)； Read(a)；goto [3] }
- 若 $X\in V_T$ & X≠ a，则 Error；
- 若 $X \in V_N$，则：

if LL(X, a)=$X\rightarrow Y_1\ Y_2 \ldots\ldots Y_n$

then { Pop(1)；Push(Y_n,.....,Y_1)；goto[3] }

else Error

Building Parse Tree During LL(1)

[1] 初始化： Stack := [ ];

root=BuildOneNode(S); Push(S, root)；

[2] 读下一个输入符： Read(a)；

[3] 若当前格局是(, #)，则成功结束；否则转下；

[4] 设当前格局为（..... X, a.....)，则

- 若X∈ V_T & X= a ，则 { Pop(1)； Read(a)；goto [3] }
- 若X∈ V_T & X≠ a ，则 Error；
- 若X ∈ V_N ，则：

if LL(X, a)=X→Y_1 Y_2 ...... Y_n

then { (X, ptr) = Pop(1);

for i=n to 1 { p[i] = BuildOneNode(Yi), Push(Y_i, p[i])； }

AddSons(ptr, p, n);

goto[3] }

else Error

4.5 LL(1) Parsing

- Main idea of LL(1) Parsing Method
- LL(1) Grammar (LL(1)文法)
- LL(1) Parsing Table (LL(1)分析表)
- LL(1) Parsing Engine (LL(1)分析驱动程序)
- LL(1) Parsing Process (LL(1)分析过程)
- LL(1) Parser Generator – LLGen、JavaCC (LL(1)分析程序的自动生成器)

LL(1) Parsing Process

P:
(1) Z → aBd
(2) B → d
(3) B → c
(4) B → bB

	a	b	c	d	#
Z	(1)				
B		(4)	(3)	(2)	

a	b	c	d

a	c	c	d

Dealing with If-Then-Else

- **CFG for If-Then-Else**

V_T = {if, then, else, other, ;, exp}

V_N = {S, Stm, ElsePart}

P:

(1) S → Stm ;

(2) Stm → if exp then Stm ElsePart

(3) Stm → other

(4) ElsePart → else Stm

(5) ElsePart → ε

Predict set:

(1)	{if, other}
(2)	{if}
(3)	{other}
(4)	{else}
(5)	{;, else}

Dealing with If-Then-Else

- LL(1) parsing table

	if	then	else	other	exp	;	#
S	(1)			(1)			
Stm	(2)			(3)			
ElsePart			(4) (5)			(5)	

每个else与其前面未匹配的最近的then相匹配!

	if	then	else	other	exp	;	#
S	(1)			(1)			
Stm	(2)			(3)			
ElsePart			(4)			(5)	

Dealing with If-Then-Else

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stack	input	action
S	if exp then if exp then other else other ;	**(1)**
Stm ;	if exp then if exp then other else other;	**(2)**
if exp then Stm ElsePart;	**if exp then** if exp then other else other;	Match(3次)
Stm ElsePart;	if exp then other else other;	**(2)**
if exp then Stm ElsePart ElsePart;	**if exp then** other else other;	Match(3次)
Stm ElsePart ElsePart;	other else other;	**(3)**
other ElsePart ElsePart;	other else other;	Match
ElsePart ElsePart;	else other;	**(4)**

(1) S → Stm ;
(2) Stm → if exp then Stm ElsePart
(3) Stm → other
(4) ElsePart → else Stm
(5) ElsePart → ε

	if	then	else	other	exp	;	#
S	(1)			(1)			
Stm	(2)			(3)			
ElsePart			(4)			(5)	

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Dealing with If-Then-Else

stack	input	action
ElsePart ElsePart;	else other;	(4)
else Stm ElsePart;	**else** other;	match
Stm ElsePart;	other;	(3)
other ElsePart;	**other**;	match
ElsePart;	;	(5)
;	**;**	match
		succeed

(1) S → Stm ;
(2) Stm → if exp then Stm ElsePart
(3) Stm → other
(4) ElsePart → else Stm
(5) ElsePart → ε

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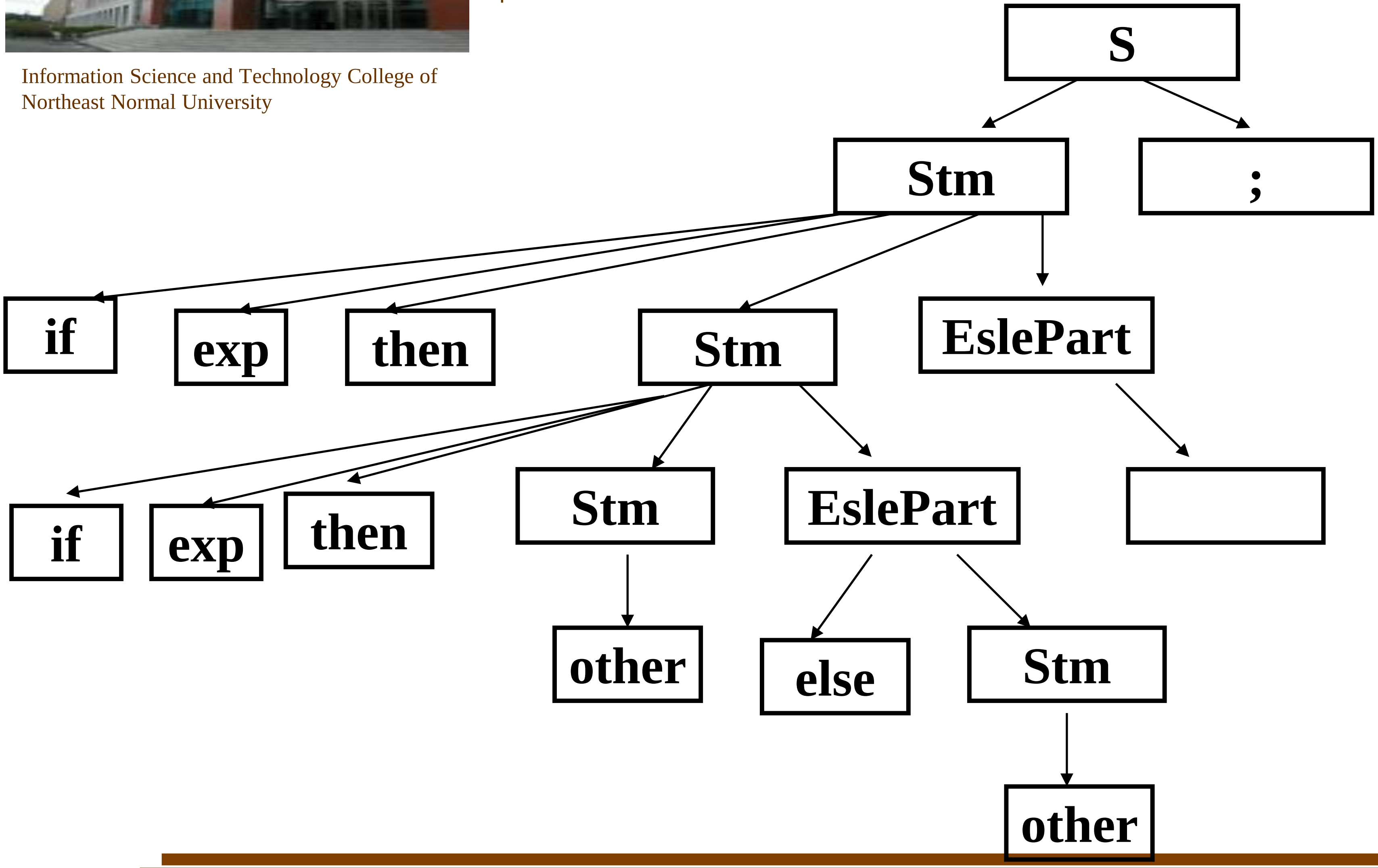

4.5 LL(1) Parsing

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LL(1) Parser Generator – LLGen

<选择部分>

<常数定义>

<终极符定义>

<产生式定义>

LLGen

终极符/产生式个数

产生式右部长度

LL(分析表)

可导空串的符号表

文法中所有符号

非LL(1)表的冲突

JavaCC

- Java Compiler Compiler (JavaCC) – The Java Parser Generator
  - http://javacc.java.net/

JavaCC源程序 Parser.jj → JavaCC编译器 → LL(K)语法分析源程序(含词法分析) Parser.java

LL(K)语法分析源程序(含词法分析) Parser.java → Java编译器javac → LL(K)语法分析程序(含词法分析) Parser.class

输入串 → 运行LL(K)语法分析程序(含词法分析) java Parser.class → 分析结果

JavaCC

- <parser_name>.java
- <parser_name>Constants.java
- <parser_name>TokenManager.java
- ParseException.java
- SimpleCharStream.java
- Token.java
- TokenMgrError.java

§ 4 Top-down Parsing

4.1 Overview of Top-down Parsing

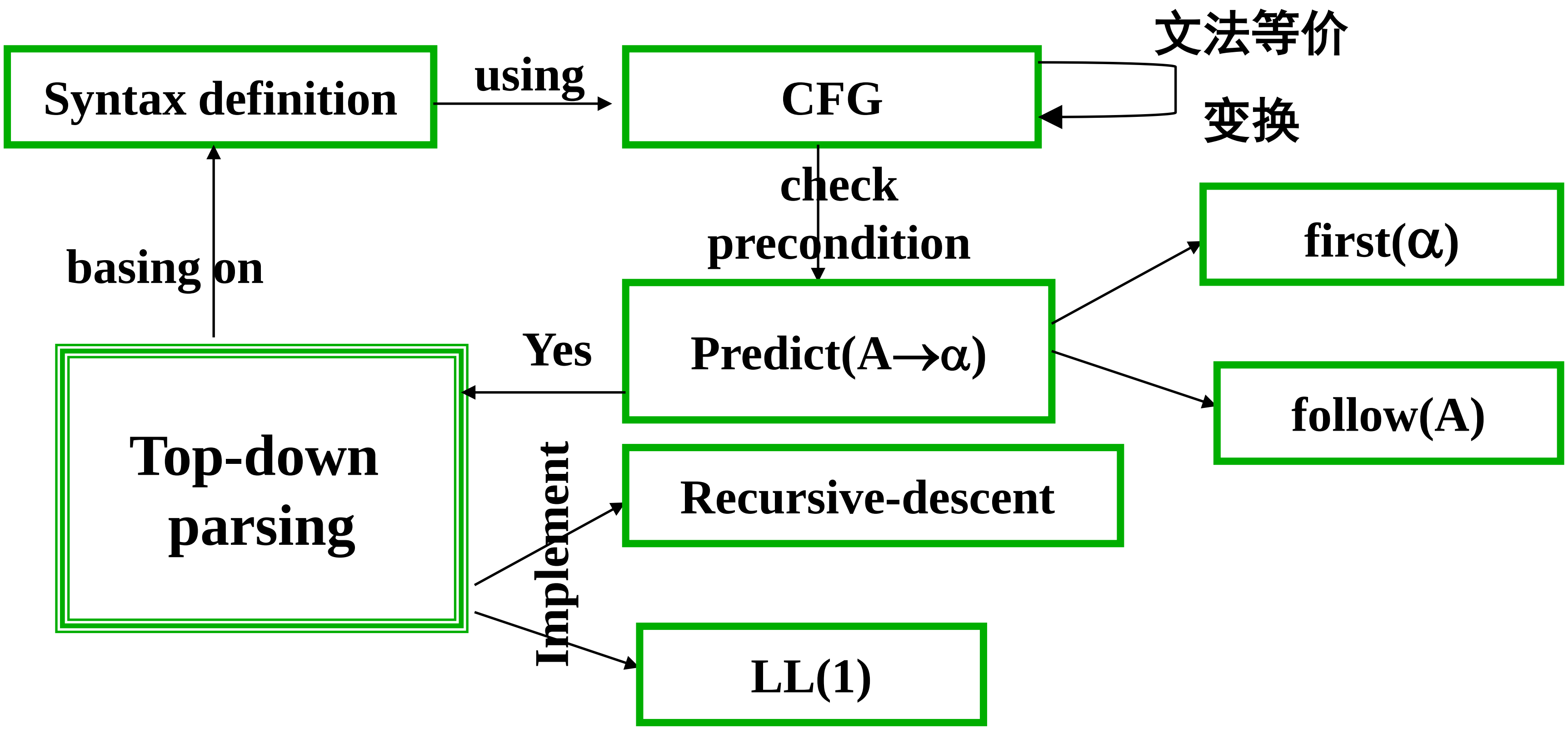
4.2 Three Important Sets

4.3 Left Recursion Removal & Left Factoring

4.4 Recursive-Descent Parsing

4.5 LL(1) Parsing

Knowledge Relation Graph



Summary

- **What is the *<u>main idea of Top-down parsing</u>*?**
- **What is the *<u>precondition</u>* of recursive-descent and LL(1) parsing?**
- **The *<u>definitions of three sets</u>* ?**
- **For a given CFG, *<u>calculate three sets</u>*?※**
- **The *<u>main idea of recursive-descent parsing</u>*?**

Summary

- **For a given CFG, *develop recursive-descent parser*?**
  - ***Calculate predict set* for each production;**
  - ***Check* whether meets the *precondition*;**
  - **If yes, *develop* function for each non-terminal symbol;**
  - ***Build parse tree* during parsing;**

Summary

- **The main idea of LL(1) parsing?**
- **LL(1) Grammar?**
- **The mechanism of LL(1) parsing?**
- **For a given CFG, develop LL(1) parser?**
  - **Calculate predict set for each production;**
  - **Check whether meets the precondition;**
  - **If yes, generate LL(1) parsing table;**
  - **LL(1) parser = LL(1) parsing table + LL(1) parsing engine**
- **Give the LL(1) parsing process?**

Summary

- **The *main idea of LL(1) parsing*?**
- ***LL(1) Grammar*?**
- **The *mechanism of LL(1) parsing*?**
- **For a given CFG, develop LL(1) parser?**
  - **Calculate predict set for each production;**
  - **Check whether meets the precondition;**
  - **If yes, generate LL(1) parsing table;**
  - **LL(1) parser = LL(1) parsing table + LL(1) *parsing engine***
  - ***Build parse tree*;**
- **Give the LL(1) parsing process?**

Assignment

- $G = \{V_T, V_N, S, P\}$
- $V_T = \{-\ ,\ (,\ ),\ id\}$
- $V_N = \{E, ET, V, VT\}$
- $S = E$
- $P = \{\ E \rightarrow -E \qquad ET \rightarrow \varepsilon$

  $E \rightarrow (E) \qquad V \rightarrow id\ VT$

  $E \rightarrow V\ \ ET \qquad VT \rightarrow (E)$

  $ET \rightarrow -E \qquad VT \rightarrow \varepsilon\ \}$

(1)Generate LL(1) Parsing table;

(2) “-(id--id)”的分析过程;