第六章 中间代码生成

控制流语句及其SDT

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控制流语句的基本文法

控制语句的3种结构

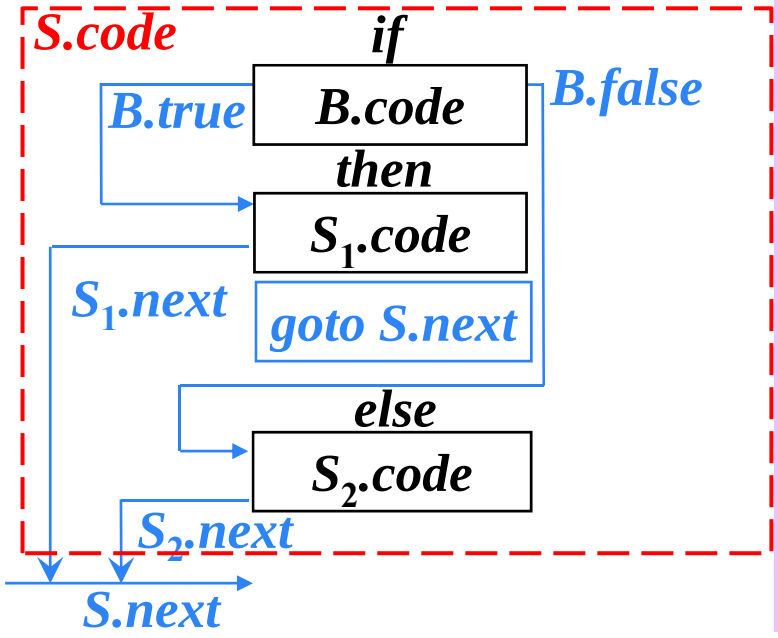
- $P \rightarrow S$
- $S \rightarrow S_1 S_2$　　顺序结构
- $S \rightarrow \text{id} = E\ ; \mid L = E\ ;$
- $S \rightarrow \text{if}\ B\ \text{then}\ S_1$　　分支结构

  $\mid \text{if}\ B\ \text{then}\ S_1\ \text{else}\ S_2$

  $\mid \text{while}\ B\ \text{do}\ S_1$　　循环结构

控制流语句的代码结构

➢ 例 $S \rightarrow if\ B\ then\ S_1\ else\ S_2$



布尔表达式B被翻译成由跳转指令构成的跳转代码

➢ 继承属性

- ➢ S.next：是一个地址，该地址中存放了紧跟在S代码之后的指令(S的后继指令)的标号
- ➢ B.true：是一个地址，该地址中存放了当B为真时控制流转向的指令的标号
- ➢ B.false：是一个地址，该地址中存放了当B为假时控制流转向的指令的标号

用指令的标号标识一条三地址指令

先预约房间，等S处理完（客人来了）再入住

生成s执行后下一条语句的标号

控制流语句的SDT

newlabel( ): 生成一个用于存放标号的新的临时变量*L*，返回变量地址

- $P \rightarrow \{ S.next = newlabel(); \} S \{ label(S.next); \}$
- $S \rightarrow \{ S_1.next = newlabel(); \} S_1$

  $\{ label(S_1.next); S_2.next = S.next ; \} S_2$

label(*L*): 将下一条三地址指令的标号赋给*L*

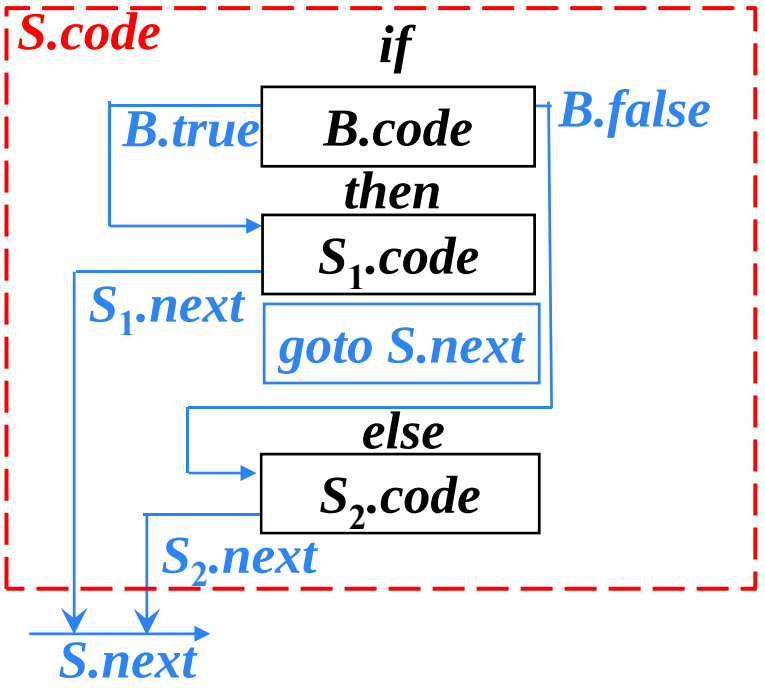
- $S \rightarrow \mathbf{id} = E ; \mid L = E ;$ 赋值语句前面已经讲了
- $S \rightarrow if\ B\ then\ S_1$

  $\mid if\ B\ then\ S_1\ else\ S_2$

  $\mid while\ B\ do\ S_1$

*if-then-else*语句的*SDT*

$S \rightarrow$ *if B then* S_1 *else* S_2

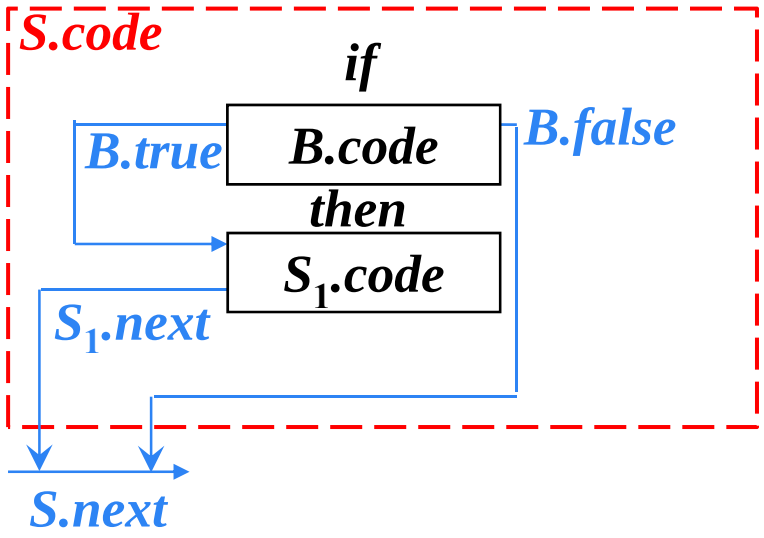


赋值，B为true的时候执行该指令

$S \rightarrow$ *if* { *B.true* = *newlabel*(); *B.false* = *newlabel*(); } *B*
then { *label*(*B.true*); S_1.*next* = *S.next*; } S_1 { *gen*(‘*goto*’ *S.next*) }
else { *label*(*B.false*); S_2.*next* = *S.next*; } S_2

*if-then*语句的*SDT*

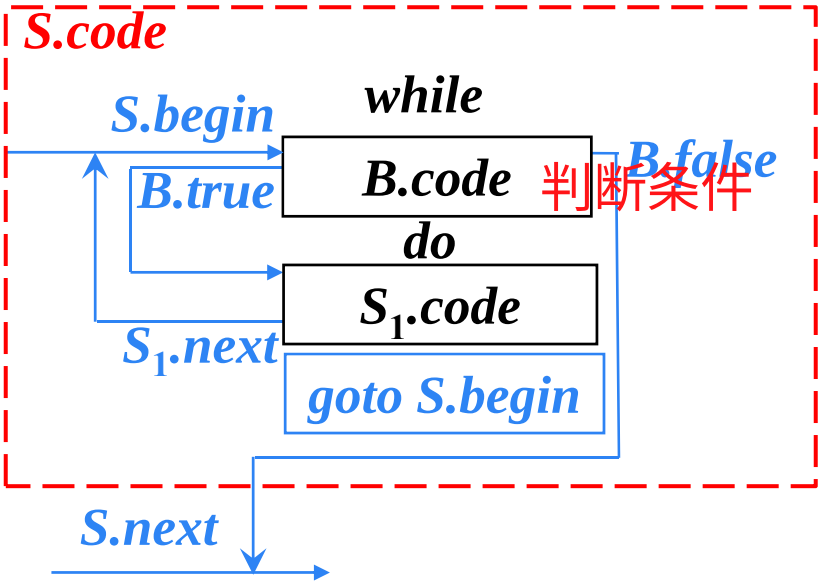
$S \rightarrow if\ B\ then\ S_1$



$S \rightarrow if$ { $B.true = newlabel(); B.false = S.next;$ } B
$then$ { $label(B.true); S_1.next = S.next;$ } S_1

*while-do*语句的*SDT*

$S \rightarrow$ *while* B *do* S_1



$S \rightarrow$ *while* {*S.begin* = *newlabel*();
label(*S.begin*);
B.true = *newlabel*();
B.false = *S.next*;} B
do { *label*(*B.true*); S_1.*next* = *S.begin*;} S_1
{ *gen*('*goto*' *S.begin*); }

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布尔表达式及其SDT

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布尔表达式的基本文法

$B \rightarrow B$ or B

| B and B

| not B

| (B)

| E relop E

| true

| false

优先级：not > and > or

关系表达式

relop（关系运算符）：

<, <=, >, >=, ==, !=

- 在跳转代码中，逻辑运算符&&、||和！被翻译成跳转指令。运算符本身不出现在代码中，布尔表达式的值是通过代码序列中的位置来表示的
- 例
  - 语句

```
if ( x<100 || x>200 && x!=y )
        x=0;
```

  - 三地址代码

```
        if x<100 goto L2
        goto L3
L3 :    if x>200 goto L4
        goto L1
L4 :    if x!=y goto L2
        goto L1
L2 :    x=0
L1 :
```

布尔表达式的*SDT*

- $B \rightarrow E_1$ relop E_2 { *gen*(‘*if* ’ E_1.*addr relop* E_2.*addr* ‘*goto*’ *B.true*);
  gen(‘*goto*’ *B.false*); }
- $B \rightarrow$ true { *gen*(‘*goto*’ *B.true*); }
- $B \rightarrow$ false { *gen*(‘*goto*’ *B.false*); }
- $B \rightarrow$ ({B_1.*true* =*B. true*; B_1.*false* =*B.false*; } B_1)
- $B \rightarrow$ not { B_1.*true* = *B.false*; B_1.*false* = *B.true*; } B_1

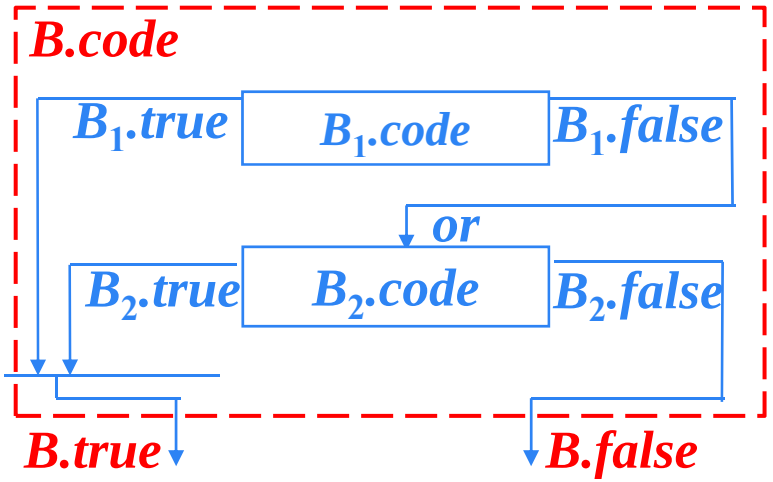
$B \rightarrow B_1$ or B_2 的SDT

- $B \rightarrow B_1$ *or* B_2

先计算B1 true false对应的值

  - $B \rightarrow \{ B_1.true = B.true;\ B_1.false = newlabel(); \} B_1$

    or $\{ label(B_1.false);\ B_2.true = B.true;\ B_2.false = B.false; \} B_2$

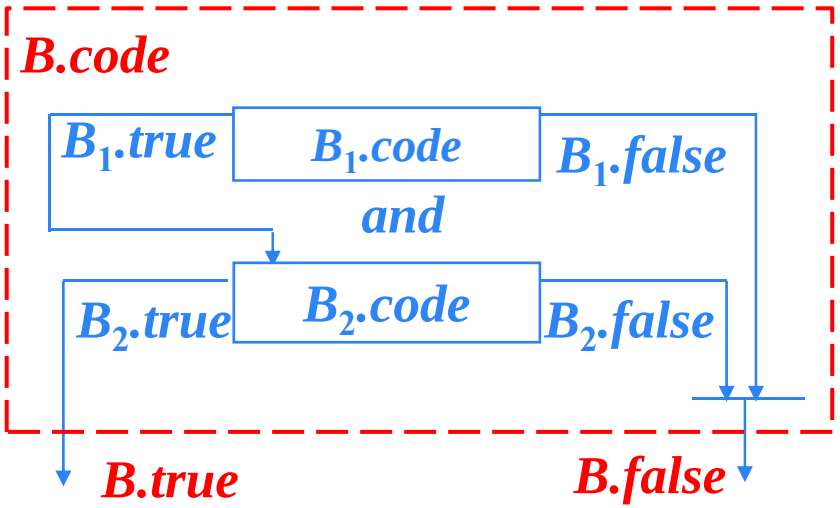


$B \rightarrow B_1$ and B_2 的*SDT*

- $B \rightarrow B_1$ *and* B_2
  - $B \rightarrow \{\ B_1.true = newlabel();\ B_1.false = B.false;\ \}\ B_1$

    and $\{\ label(B_1.true);\ B_2.true = B.true;\ B_2.false = B.false;\ \} B_2$

存放指令编号的临时变量



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控制流翻译的例子

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控制流语句的SDT

- $P \rightarrow \{a\}S\{a\}$
- $S \rightarrow \{a\}S_1\{a\}S_2$
- $S \rightarrow \text{id}=E;\{a\} \mid L=E;\{a\}$
- $E \rightarrow E_1+E_2\{a\} \mid -E_1\{a\} \mid (E_1)\{a\} \mid \text{id}\{a\} \mid L\{a\}$
- $L \rightarrow \text{id}[E]\{a\} \mid L_1[E]\{a\}$
- $S \rightarrow \text{if } \{a\}B \text{ then } \{a\}S_1$
  $\mid \text{if } \{a\}B \text{ then } \{a\}S_1 \text{ else } \{a\}S_2$
  $\mid \text{while } \{a\}B \text{ do } \{a\}S_1\{a\}$
- $B \rightarrow \{a\}B \text{ or } \{a\}B \mid \{a\}B \text{ and } \{a\}B \mid \text{not } \{a\}B \mid (\{a\}B)$
  $\mid E \text{ relop } E\{a\} \mid \text{true}\{a\} \mid \text{false}\{a\}$

*SDT*的通用实现方法

- 任何*SDT*都可以通过下面的方法实现
  - 首先建立一棵语法分析树，然后按照从左到右的深度优先顺序来执行这些动作

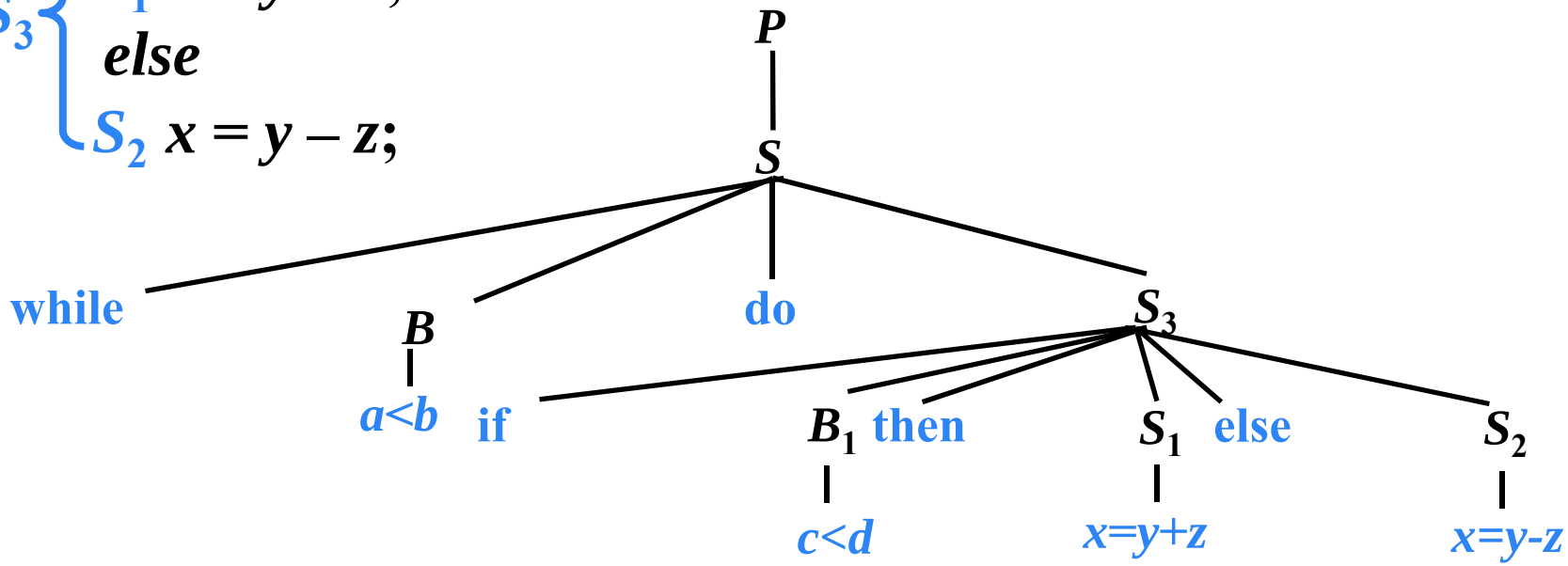
控制流语句的SDT

- $P \rightarrow \{a\}S\{a\}$
- $S \rightarrow \{a\}S_1\{a\}S_2$
- $S \rightarrow \text{id}=E;\{a\} \mid L=E;\{a\}$
- $E \rightarrow E_1+E_2\{a\} \mid -E_1\{a\} \mid (E_1)\{a\} \mid \text{id}\{a\} \mid L\{a\}$
- $L \rightarrow \text{id}[E]\{a\} \mid L_1[E]\{a\}$
- $S \rightarrow \text{if } \{a\}B \text{ then } \{a\}S_1$
  $\mid \text{if } \{a\}B \text{ then } \{a\}S_1 \text{ else } \{a\}S_2$
  $\mid \text{while } \{a\}B \text{ do } \{a\}S_1\{a\}$
- $B \rightarrow \{a\}B \text{ or } \{a\}B \mid \{a\}B \text{ and } \{a\}B \mid \text{not } \{a\}B \mid (\{a\}B)$
  $\mid E \text{ relop } E\{a\} \mid \text{true}\{a\} \mid \text{false}\{a\}$

例

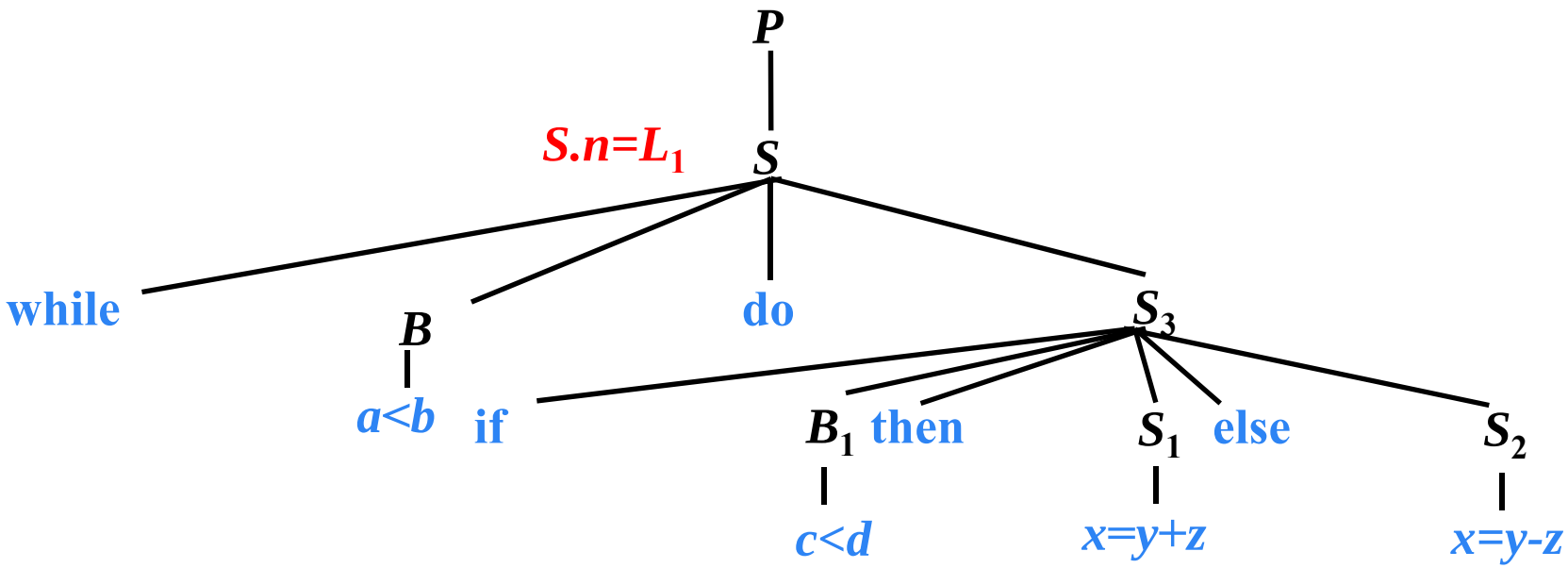
```
while a < b do
  if c < d then
    x = y + z;
  else
    x = y – z;
```

B: `a < b`　　B_1: `c < d`　　S_3: `if c < d then x = y + z; else x = y – z;`　　S_1: `x = y + z;`　　S_2: `x = y – z;`



例

$P \rightarrow \{\ S.next = newlabel(\ );\ \} S \{\ label(S.next);\}$



例

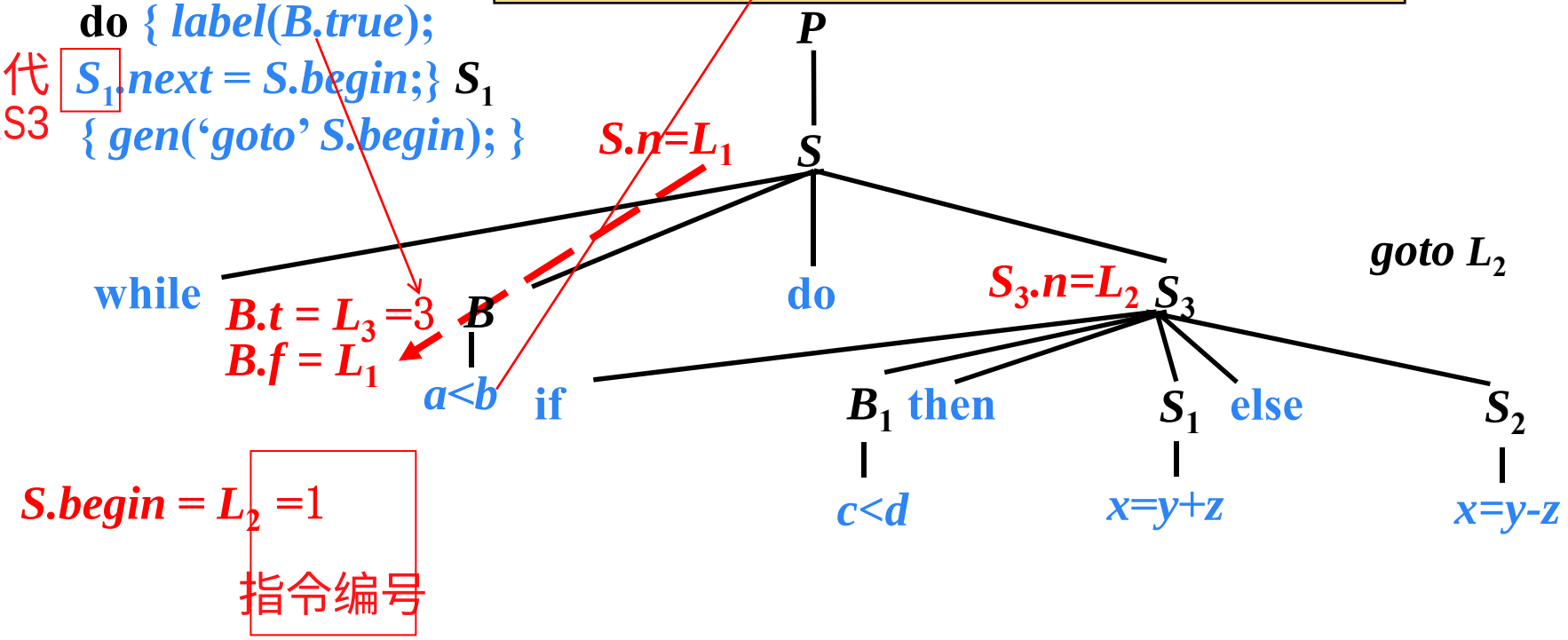
$S \rightarrow$ while {*S.begin = newlabel( );*
label(S.begin);
B.true = newlabel( );
B.false = S.next;} B
do { *label(B.true);*
S_1*.next = S.begin;*} S_1
{ *gen('goto' S.begin);* }

在树中代表的是S3

$B \rightarrow E_1$ relop E_2
{ *gen('if ' E_1.addr relop E_2.addr 'goto' B.true);*
gen('goto ' B.false); }

1: *if a < b goto* L_3
2: *goto* L_1

生成具体的指令

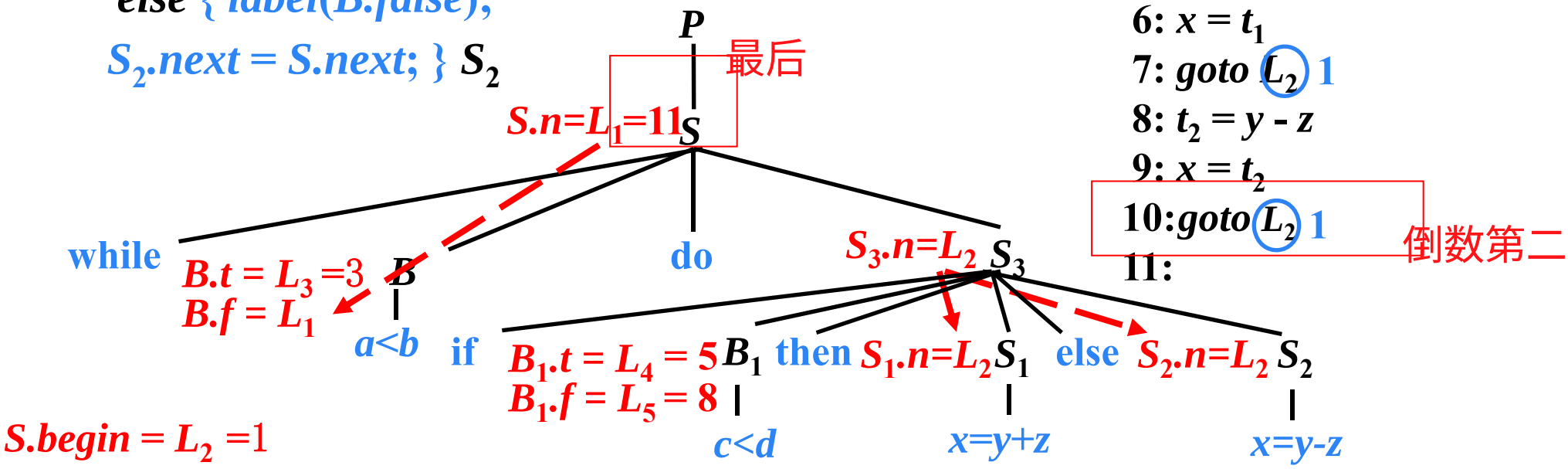


S.begin = L_2 =1

指令编号

例

$S \rightarrow$ *if* { *B.true = newlabel( ); B.false = newlabel( );* } B
then { *label(B.true); S_1.next = S.next;* } S_1
{ *gen('goto' S.next);* }
else { *label(B.false);*
S_2*.next = S.next;* } S_2



最后还要进行标号和地址的绑定

1: *if a < b goto* L_3 (3)
2: *goto* L_1 11
3: *if c < d goto* L_4 (5)
4: *goto* L_5 8
5: $t_1 = y + z$
6: $x = t_1$
7: *goto* L_2 1
8: $t_2 = y - z$
9: $x = t_2$
10: *goto* L_2 1
11:

倒数第二

语句“*while a<b do if c<d then x=y+z else x=y-z*”的三地址代码

1: *if a < b goto* 3
2: *goto* 11
3: *if c < d goto* 5
4: *goto* 8
5: $t_1 = y + z$
6: $x = t_1$
7: *goto* 1
8: $t_2 = y - z$
9: $x = t_2$
10: *goto* 1
11:

1: (*j*<, *a*, *b* , 3)
2: (*j* , - , - , 11)
3: (*j*<, *c*, *d* , 5)
4: (*j* , - , - , 8)
5: (+ , *y* , *z* , t_1)
6: (= , t_1, - , *x*)
7: (*j* , - , - , 1)
8: (- , *y*, *z* , t_2)
9: (= , t_2, - , *x*)
10: (*j* , - , - , 1)
11:

四元式形式

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