写在前面：第九次作业题量较大，书写字数较多，且无完全标准参考答案。下面给出两位同学的作业作为参考。

10.1

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10.1. (a). while (1<x && y>1)
if (-n+1<x*y) a=1
else b=a

规范归约：

①. 1<x && y>1 部分：

⇒ E<x … E.place = 't1 . E1.code = [t1 = 1]

⇒ E1<E2 … E2.place = 'x

⇒ B && y>1 B.tc = (L1), B.fc = (L2); B.code = [t1 = 1; if t1<x then L1 else L2]

⇒ B && E>1 (类似 E2) ⇒ B && E>E (类似 E1)

⇒ B1 && B2 B2.tc = (L3), B2.fc = (L4), B2.code = [t2 = 1; if y>t2 then L3 else L4]

⇒ B B.tc = (L3), B.fc = (L2, L4) B.code = [(B1代码); label L1; (B2代码)]

②. -n+1<x*y 部分：

⇒ -E+1 … E.place = 'n

⇒ E+1 … E.place = 't11 E1.code = [t11 = -n]

⇒ E1+E2 … E2.place = 't12 E2.code = [t12 = 1]

⇒ E<x*y E.place = 't13 E.code = [t11 = -n; t12 = 1; t13 = t11 + t12]

x*y 过程类似，得到 E1<E2 E2.place = 't14 , E2.code = [t14 = x*y]

⇒ B B.tc = (L11). B.fc = (L12) B.code = [(左式code) (右式code); if t13 < t14 then L11 else L12]

③. 整体：while (B) if(B) a=1 else b=a

⇒ … if (B) S1 else b=a S1.place = a code = [a = 1];

⇒ … if (B) S1 else S2 S2.place = b code = [b = a];

No:

Date:

⇒ while(B) S S.code = [(②B代码) label L1; a=1; goto L20; label L12; b=a; label L20]

⇒ S S.code = [label L21; (①B代码) label L3; (上述S代码) goto L21; label L2, L4]

三地址代码段：

```
label L21;
    t1=1; if t1<x then L1 else L2;
    label L1;
    t2=1; if y>t2 then L3 else L4;
label L3;
    t11=-n; t12=1; t13=t11+t12;
    t14=x*y;
    if t13<t14 then L11 else L12;
  label L11;
    a=1; goto L20;
  label L12;
    b=a;
    label L20;
  goto L21;
label L2; label L4;
```

(b).

```
if(x)
    while(y){
        if(x>y) goto next;
        x=x*y
    }
else{
    y=x*y;
    next: print y
}
```

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① while (y) 部分：

while (E) {…} E.place = 'y' E.code = [ ]

⇒ while (B) {…} B.tc = {L1} B.fc = {L2} code = [if y!=0 then L1 else L2]

⇒ … {if (B) goto nextS; …} B.tc = {L3} fc = {L4} code = [if x>y then L3 else L4]

⇒ … {if (B) S; …} S.code = [goto L100;]

⇒ … {S; x=x*y} S.code = [if (x>y) L3 else L4; label L3; goto L100; label L4;] ⓐ

⇒ {S; E=E*E} ⇒ {S; E=E} ⇒ {S1; S2} ⇒ S2.code = [t1 = x*y; x = t1;] ⓑ

⇒ while (B) {S; S} ⇒ while (B) {S} ⇒ while (B) S

⇒ S S.code = [label L5; if y!=0 then L1 else L2; label L1; ⓐ ⓑ goto L5; label L2]

类似，else 分支过程类似，省略，结果为：

⇒ if (B) B.tc = L21, B.fc = L22 B.code = [if x!=0 then L21 else L22]

⇒ if (B) S1 else S2: S2.code = [t21 = x*y; y = t21; label L100; print y;]

⇒ S S.code = [if x!=0 then L21 else L22; label L21: (S1代码) label L22: (S2代码)]

三地址代码段：

```
if x!=0 then L21 else L22
label L21:
  label L5; if y!=0 then L1 else L2
    label L1; if (x>y) then L3 else L4
      label L3: goto L100; label L4:
    t1 = x*y; x = t1;
  goto L5; label L2;
label L22:
  t21 = x*y; y = t21; label L100:
  print y;
```

10. 1. a)

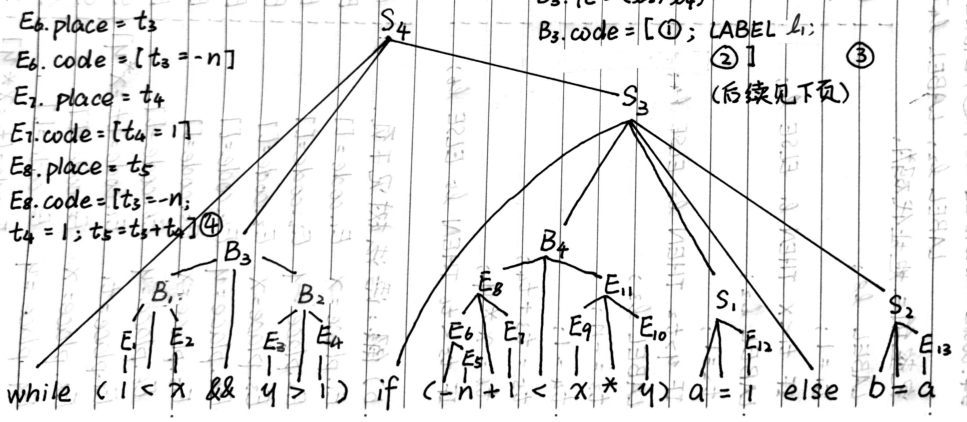
解:

$E_1.place = t_1$
$E_1.code = [t_1 = 1]$
$E_2.place = x$
$E_2.code = []$
$E_3.place = y$
$E_3.code = []$
$E_4.place = t_2$
$E_4.code = [t_2 = 1]$
$E_5.place = n$
$E_5.code = []$
$E_6.place = t_3$
$E_6.code = [t_3 = -n]$
$E_7.place = t_4$
$E_7.code = [t_4 = 1]$
$E_8.place = t_5$
$E_8.code = [t_3 = -n;$
$t_4 = 1; t_5 = t_3 + t_4]$ ④

$E_9.place = x$
$E_9.code = []$
$E_{10}.place = y$
$E_{10}.code = []$
$E_{11}.place = t_6$
$E_{11}.code = [t_6 = x * y]$ ⑤
$E_{12}.place = t_7$
$E_{12}.code = [t_7 = 1]$
$E_{13}.place = a$
$E_{13}.code = []$
$S_1.code = [t_7 = 1; a = t_7]$ ⑦

$S_2.code = [b = a]$ ⑧
$B_1.tc = (l_1)$.
$B_1.fc = (l_2)$
$B_1.code = [t_1 = 1;$
IF $t_1 < x$ THEN l_1 ELSE $l_2]$ ①
$B_2.tc = (l_3)$
$B_2.fc = (l_4)$
$B_2.code = [t_2 = 1;$
IF $y > t_2$ THEN l_3 ELSE $l_4]$ ②
$B_3.tc = (l_3)$
$B_3.fc = (l_2, l_4)$
$B_3.code = [$① ; LABEL l_1;
②] ③

(后续见下页)



$B_4.tc = (l_5)$ $B_4.fc = (l_6)$

$B_4.code = [④ ; ⑤ ; IF\ t_5 < t_6\ THEN\ l_5\ ELSE\ l_6]$ ⑥

$S_3.code = [⑥ ; LABEL\ l_5 ; ⑦ ; GOTO\ l_7 ; LABEL\ l_6 ; ⑧ ; LABEL\ l_7]$ ⑨

$S_4.code = [LABEL\ l_8 ; ③ ; LABEL\ l_3 ; ⑨ ; GOTO\ l_8 ;$
$LABEL\ l_2 ; LABEL\ l_4]$.

完整的三地址代码为：

```
LABEL l8;
t1 = 1;
IF t1<x THEN l1 ELSE l2;
LABEL l1;
t2 = 1;
IF y>t2 THEN l3 ELSE l4;
LABEL l3;
t3 = -n;
t4 = 1;
t5 = t3 + t4;
t6 = x * y;
IF t5 < t6 THEN l5 ELSE l6;
LABEL l5;
t7 = 1; a = t7;
GOTO l7;
LABEL l6;
b = a;
LABEL l7;
GOTO l8;
LABEL l2;
LABEL l4;
```

b) 解：语法树见下页.

$E_1.place = x$ $E_1.code = []$

$E_2.place = y$ $E_2.code = []$

$E_3.place = x$ $E_3.code = []$

$E_4.place = y$ $E_4.code = []$

$E_5.place = x$ $E_5.code = []$

$E_6.place = y$ $E_6.code = []$

$E_7.place = t_1$ $E_7.code = [t_1 = x * y]$

$E_8.place = x$ $E_8.code = []$

$E_9.place = y$ $E_9.code = []$

$E_{10}.place = t_2$ $E_{10}.code = [t_2 = x * y]$

$E_{11}.place = y$ $E_{11}.code = []$

$B_1.tc = (l_1)$ $B_1.fc = (l_2)$

$B_1.code = [IF\ x != 0\ THEN\ l_1\ ELSE\ l_2]$ ①

$B_2.tc = (l_3)$ $B_2.fc = (l_4)$

$B_2.code = [IF\ y != 0\ THEN\ l_3\ ELSE\ l_4]$ ②

$B_3.tc = (l_5)$ $B_3.fc = (l_6)$

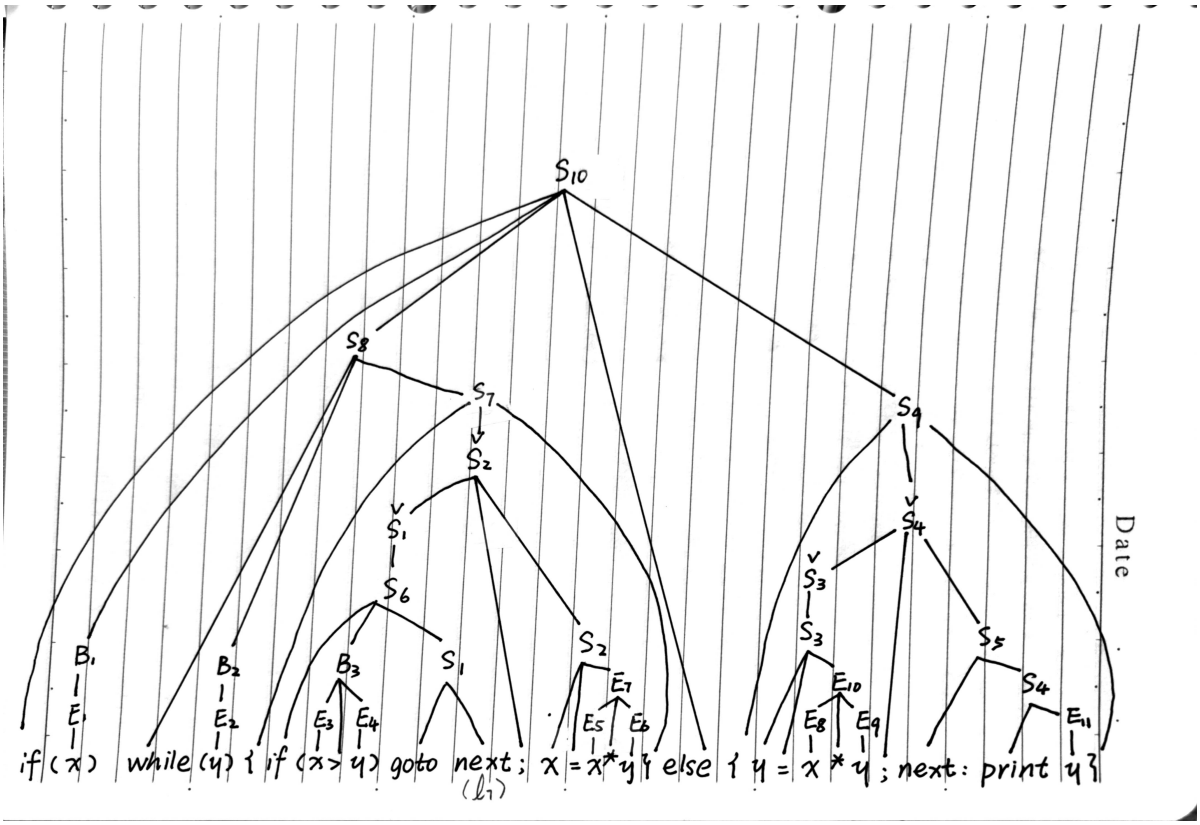
$B_3.code = [IF\ x > y\ THEN\ l_5\ ELSE\ l_6]$ ③

$S_1.code = [GOTO\ l_7]$

$S_2.code = [t_1 = x * y ; x = t_1]$ ④

$S_3.code = [t_2 = x * y ; y = t_2]$ ⑤

$S_4.code = [PRINT\ y]$


S10
S8
S7
S9
S2
S1
S4
S6
S3
S3
S5
S2
S4
B1
B2
B3
S1
E7
E10
E1
E2
E3
E4
E5
E6
E8
E9
E11
if (x) while (y) { if (x > y) goto next; x = x * y; } else { y = x * y; next: print y }
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$S_5.code = [LABEL\ l_7;\ PRINT\ y]$ ⑥

$S_6.code = [③; LABEL\ l_5; GOTO\ l_7; LABEL\ l_6]$ ⑦

$S_1.code = ([⑦])$ $S_2.code = ([⑦].[④])$

$S_3.code = ([⑤])$ $S_4.code = ([⑤].[⑥])$

$S_7.code = [⑦;④]$ $S_9.code = [⑤;⑥]$ ⑧

$S_8.code = [LABEL\ l_8; ②; LABEL\ l_3; ⑦; ④; GOTO\ l_8; LABEL\ l_4]$

$S_{10}.code = [①; LABEL\ l_1; ⑧; GOTO\ l_9; LABEL\ l_2; ⑤; ⑥; LABEL\ l_9]$

完整的三地址代码为：

IF x!=0 THEN l_1 ELSE l_2;	LABEL l_2;
LABEL l_1;	$t_2 = x * y$; $y = t_2$;
LABEL l_8;	LABEL l_7;
IF y!=0 THEN l_3 ELSE l_4;	PRINT y;
LABEL l_3;	LABEL l_9;
IF x>y THEN l_5 ELSE l_6;	
LABEL l_5;	
GOTO l_7;	
LABEL l_6;	
$t_1 = x * y$; $x = t_1$;	
GOTO l_8;	
LABEL l_4;	
GOTO l_9;	

10.2 解：设计的文法为：

S → for (S; B; S) S { l = newlabel();
S[0].code = S[1].code ++ gen[LABEL ?l] ++
B.code ++ gen_l[LABEL ?B.tc] ++ S[3].code
++ S[2].code ++ gen[GOTO ?l] ++ gen_l[LABEL
?B.fc]; }

10.2

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10.2, 文法:

S → for (S; B; S) S {

l = newlabel();

S[0].code =

S[1].code ++

gen[LABEL ?l] ++

B.code ++

gen-t[LABEL ?B.tc] ++

S[3].code ++ S[2].code ++

gen[GOTO ?l] ++

gen-t[LABEL ?B.fc] }

for(i=0; i<100; i=i+1) print i

省略中间 ⇒ for(S_1; B; S_2) S_3 S_1.code = [t_1=0; i=t_1]

S_2.code = [t_2=i+1; i=t_2]

S_3.code = [print i]

B.code = [t_3=100; if i<t_3 then L_1 else L_2]

tc=(L_1), fc=(L_2)

⇒ S code= t_1=0; i=t_1;

三地址代码段

~~label L_{10};~~

t_3=100; if i<t_3 then L_1 else L_2;

label L_1

print i; t_2=i+1; i=t_2;

goto L_{10};

~~label L_2;~~

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Date

$S_5.code = [LABEL\ l_7;\ PRINT\ y]$ ⑥

$S_6.code = [③; LABEL\ l_5; GOTO\ l_7; LABEL\ l_6]$ ⑦

$S_1.code = ([⑦])$ $S_2.code = ([⑦].[④])$

$S_3.code = ([⑤])$ $S_4.code = ([⑤].[⑥])$

$S_7.code = [⑦;④]$ $S_9.code = [⑤;⑥]$ ⑧

$S_8.code = [LABEL\ l_8; ②; LABEL\ l_3; ⑦; ④; GOTO\ l_8; LABEL\ l_4]$

$S_{10}.code = [①; LABEL\ l_1; ⑧; GOTO\ l_9; LABEL\ l_2; ⑤; ⑥; LABEL\ l_9]$

完整的三地址代码为：

IF x!=0 THEN l_1 ELSE l_2;	LABEL l_2;
LABEL l_1;	$t_2 = x * y$; $y = t_2$;
LABEL l_8;	LABEL l_7;
IF y!=0 THEN l_3 ELSE l_4;	PRINT y;
LABEL l_3;	LABEL l_9;
IF x>y THEN l_5 ELSE l_6;	
LABEL l_5;	
GOTO l_7;	
LABEL l_6;	
$t_1 = x * y$; $x = t_1$;	
GOTO l_8;	
LABEL l_4;	
GOTO l_9;	

10.2 解：设计的文法为：

S → for (S; B; S) S { l = newlabel();
S[0].code = S[1].code ++ gen[LABEL ?l] ++
B.code ++ gen_l[LABEL ?B.tc] ++ S[3].code
++ S[2].code ++ gen[GOTO ?l] ++ gen_l[LABEL
?B.fc]; }

题给语句的带注释语法树为(注释在树外给出):

$E_1.place = t_1$ $E_1.code = [t_1 = 0]$ $E_2.place = t_2$ $E_2.code = [t_2 = 100]$

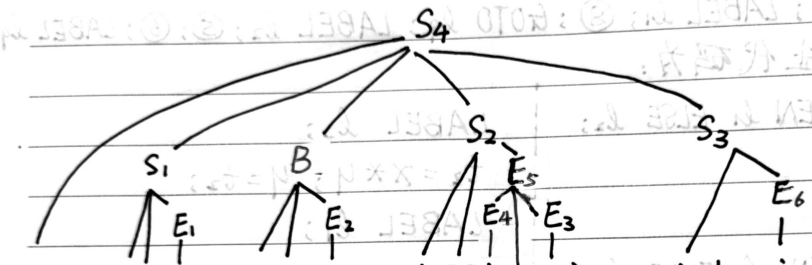
$E_3.place = t_3$ $E_3.code = [t_3 = 1]$ $E_4.place = i$ $E_4.code = []$

$E_5.place = t_4$ $E_5.code = [t_4 = i + t_3]$ $S_2.code = [t_3 = 1; t_4 = i + t_3; i = t_4]$

$E_6.place = i$ $E_6.code = []$ $S_3.code = [PRINT\ i]$

$S_1.code = [t_1 = 0; i = t_1]$ $B.tc = (l_1)$ $B.fc = (l_2)$

$B.code = [t_2 = 100; IF\ i < t_2\ THEN\ l_1\ ELSE\ l_2]$



for (i = 0 ; i < 100 ; i = i + 1) print i

完整的三地址代码(也是 S_4 的 code 域的值)为:

$t_1 = 0$; $i = t_1$

LABEL l_3;

$t_2 = 100$;

IF $i < t_2$ THEN l_1 ELSE l_2;

LABEL l_1;

PRINT i;

$t_3 = 1$; $t_4 = i + t_3$;

$i = t_4$;

GOTO l_3;

LABEL l_2;

10.3

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Date:

10.3, (a). $S \to$ for d := E_1 to E_2 do S

(b). 输出:

MAXINT - 5 的值

MAXINT - 4

... -3

.. -2

.. -1

MAXINT 的值.

(c). { l1=newlabel(); l2=newlabel(); l3=newlabel(); l4=newlabel(); l5=newlabel();

S[0].code =

E[1].code ++ E[2].code

++gen[IF ? E[1].place <= ? E[2].place THEN ? l1 ELSE ? l2]

++gen[LABEL ? l1]

++gen[? getn(d) = ? E[1].place]

++S[1].code

++gen[LABEL ? l3]

++gen[IF ? getn(d) != ? E[2].place THEN ? l4 ELSE ? l5]

++gen[LABEL ? l4]

++gen[? getn(d) = ? getn(d) + 1]

++S[1].code ++gen[GOTO ? l3]

++gen[LABEL ? l2]

++gen[LABEL ? l5]

}

(d). for i := initial to final do

writeln(i)

省略中间⇒ for d_1 := d_2 to d_3 do

$d_4(d_5)$

⇒ for d_1 := E_1 to E_2 do E_1.place='initial . E_2.place='final

$d_4(E)$ 其中 $d_4(E) \Rightarrow d_4(R) \Rightarrow d_4(\check{R}R) \Rightarrow d_4(R) \Rightarrow S$

⇒ S S.code= if initial <= final then l1 else l2 S.code = [PAR i; CALL writeln@label, 1] =

label l1: i = initial;

par i; call writeln @label, 1

label l3:

if i != final then l4 else l5

label l4: i = i+1;

par i; call writeln @label, 1; goto l3;

label l2; label l5;

Date

10.3 a) 解: S → for d := E to E do S

b) 解: 程序将依次输出从 MAXINT-5 到 MAXINT 共6个整数。

c) 解: S → for d := E to E do S

{t1 = newvar();

l1 = newlabel(); l2 = newlabel(); l3 = newlabel();

l4 = newlabel(); ll = newlabel(); v = getn(d);

S.code = E[1].code ++ E2.code ++

gen [IF ?E[1].place <= ?E[2].place THEN ?l1 ELSE ?l2]

++ gen [LABEL ?l1] ++ gen [?v = ?E[1].place]

++ S.code ++ gen [LABEL ll]

++ gen [IF ?v != ?E[2].place THEN ?l3 ELSE ?l4]

++ gen [PAR ?v]

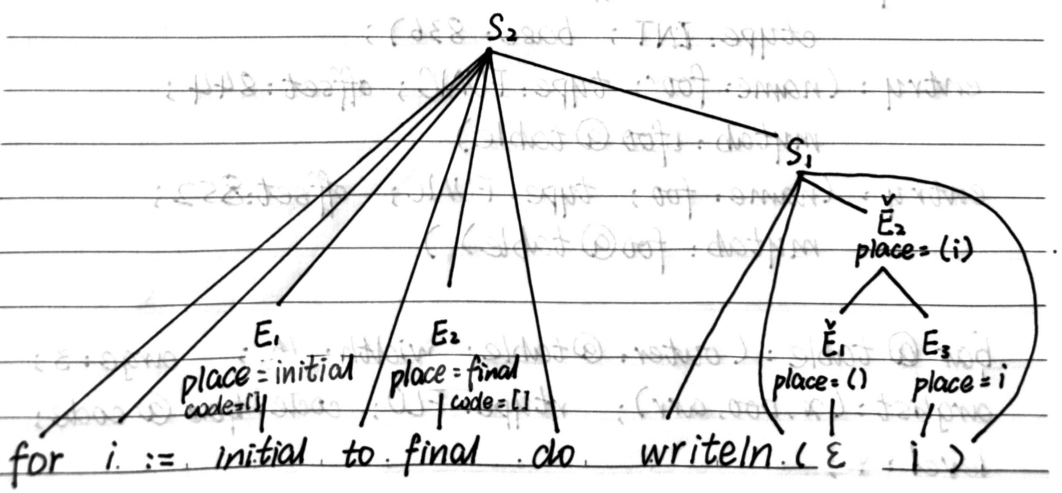
++ gen [?t1 = CALL succ @ label, 1]

++ gen [?v = ?t1] ++ S.code

++ gen [GOTO ?ll] ++ gen [LABEL l2]

++ gen [LABEL ?l4] }

d) 解: 带注释语法树如下. 部分属性在树外标出:



S_1.code = [PAR i ; CALL writeln @ label , 1]

S_2.code = [IF initial <= final THEN l1 ELSE l2 ;
LABEL l1 ;
i = initial ; PAR i ; CALL writeln @label , 1 ;
LABEL ll ;
IF i != final THEN l3 ELSE l4 ;
LABEL l3 ;
PAR i ; t1 = CALL succ @label , 1 ; i = t1 ;
PAR i ; CALL writeln @ label , 1 ;
GOTO ll ;
LABEL l2 ;
LABEL l4 ;]

10.4 解: @table : (outer : NULL ; width : 852 ; argc : 0 ;
arglist : NIL ; rtype : INT ; code : @ code ; level : 0 ;
entry : (name : x ; type : INT ; offset : 4) ;
entry : (name : z ; type : FLO ; offset : 12) ;
entry : (name : a ; type : ARRAY ; dims : 2 ; dim[0] : 10 ;
dim[1] : 20 ; etype : INT ; base : 812) ;
entry : (name : b ; type : ARRAY ; dims : 1 ; dim[0] : 6 ;
etype : INT ; base : 836) ;
entry : (name : bar ; type : FUNC ; offset : 844 ;
mytab : bar @table)
entry : (name : foo ; type : FUNC ; offset : 852 ;
mytab : foo @ table))

foo @ table : (outer : @table ; width : 16 ; argc : 3 ;
arglist : (x , boo , arr) ; rtype : FLO ; code : foo @ code ;
level : 1 ;

10.4

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10.4.

@table: (outer: NULL, width: 848 argc: 0, arglist: NIL, rtype: INT

code: [$t_1 = 2$; PAR t_1 ; PAR bar ; PAR a; t_2= CALL foo@label, 3
PRINT t_2]

entry: (name: x, type: INT, offset: 4)
(name: z -- FLOAT -- 8)
(a ARRAY base: 808 etype: INT dims: 2 dim: (10, 20))
(b ARRAY base: 832 INT (6))
(bar FUNC offset: 840 mytab: bar@table)
(foo FUNC 848 foo@table)

foo@table: (outer: @table, width: 16 argc: 3 arglist: (x, boo, arr) rtype: FLOAT

code: $t_2 = 0$; if x == t_2 then l1 else l2

label l1: $t_3 = 0$; $t_4 = 0$; $t_5 = t_3 * 20$; $t_6 = t_5 + t_4$; $t_7 = t_6 * 4$;
t_8 = arr[t_7] ; PAR t_8 ; t_9= CALL boo@label, 1 ; goto l3
z=t_9

label l2: $t_{13} = x$; $t_{141} = 2$; $t_{142} = t_{141} * x$; $t_{15} = t_{13} * 20$; $t_{16} = t_{15} + t_{14}$
$t_{17} = t_{16} * 4$; t_{18} = arr[t_{17}] t_{19} = CALL boo@label, 1 return t_{19}

label l3:

entry: (name: x INT 4
(boo FUNPTT 12 FLOAT)
(arr ARRPTT 16 INT)

bar@table: (outer: @table width 8 argc: 1 arglist (brr) rtype: float

code: $t_{21} = 0$; $t_{22} = t_{21} * 4$; t_{23} = brr[t_{22}] ;
$t_{31} = 5$; $t_{32} = t_{31} * 4$; t_{33} = brr[t_{32}] ;
$t_{41} = t_{23} + t_{33}$; $x = t_{41}$; return x ;

entry: (brr ARRPTT 4 INT)
(x FLOAT 8

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