UCS1602:
COMPILER DESIGN

TAC – Assignment statement

&

Boolean expression

Session Outcomes

- At the end of this session, participants will be able to
  - Understand the concepts of intermediate code generation of assignment statement
  - Three address code generation of Boolean expression

Outline

- Intermediate code
- Assignment statement
- Boolean expressions

Assignment Statements

$P \rightarrow M\ D$

$M \rightarrow \varepsilon$

$D \rightarrow D\ ;\ D \mid$ **id** $: T \mid$ proc **id** $N\ D\ ;\ S$

$N \rightarrow \varepsilon$

$S \rightarrow S$ **;** S

$S \rightarrow$ **id :=** E

{ *p* := *lookup*(**id**.name);
  if *p* = nil **then**
    error()
  else
    emit(**id**.place ':=' *E*.place)
}

Assignment Statements Cont…

$E \rightarrow E_1$ **+** E_2 { E.place := *newtemp*();
emit(E.place ':=' E_1.place '+' E_2.place) }

$E \rightarrow E_1$ ***** E_2 { E.place := *newtemp*();
emit(E.place ':=' E_1.place '*' E_2.place) }

$E \rightarrow$ **-** E_1 { E.place := *newtemp*();
emit(E.place ':=' 'uminus' E_1.place) }

$E \rightarrow$ **(** E_1 **)** { E.place := E_1.place }

$E \rightarrow$ **id** { *p* := *lookup*(**id**.name);
if *p* = nil **then** *error*()
else
E.place := **p**
}

Type conversions within assignments

- Reject certain mixed type conversions

Or

- Generate appropriate type conversion
- Consider only two datatype integer and real
- Consider the grammar for assignment statement.
- Introduce a new attribute E.Type

Semantic action for E → $E_1 + E_2$

```
E.place := newtemp();
if E1.Type:=integer and E2.Type:= integer then
{   emit(E.place ':=' E1.place 'int+' E2.place);
    E.Type:=integer;        }
else if E1.Type:=real and E2.Type:= real then
{   emit(E.place ':=' E1.place 'real+' E2.place);
    E.Type:=real;           }
else if E1.Type:=integer and E2.Type:= real then
{   u:= newtemp();
    emit(u:='inttoreal' E1.place);
    emit(E.place ':=' u 'real+' E2.place);
    E.Type:=real;           }
else if E1.Type:=real and E2.Type:= integer then
{   u:= newtemp();
    emit(u:='inttoreal' E2.place);
    emit(E.place ':=' E1.place 'real+' u);
    E.Type:=integer;        }
else E.Type:=error
```

Example

real x,y;

int i,j;

x:=y+i*j;

TAC:

t1:=I int * j

t2=inttoreal t1

t3:=y real t2

x:=t3

Boolean Expressions

Boolean Expressions

E→ E or E

E→ E and E

E→ not E

E→ (E)

E→ id relop id

E→ true

E→ false

1. Numerical Representation
2. Flow of control Statements

Numerical Representation

a or b and not c

t1 := not c
t2 := b and t1
t3 := a or t2

a < b

100: if a < b goto 103
101: t1 := 0
102: goto 104
103: t1 := 1
104:

Translation Scheme

E → E1 *or* E2	{E.place := newtemp(); emit (E.place ': =' E1.place '*or*' E2.place); }
E → E1 *and* E2	{E.place := newtemp(); emit (E.place ': =' E1.place '*and*' E2.place);}
E → *not* E	{E.place := newtemp(); emit (E.place ': =' '*not*' E.place);}
E → (E1)	{ E.place := E1.place; }
E → *id1 relop id2*	{ E.place ': =' newtemp(); emit ('if' *id1*.place *relop*.op *id2*.place , '*goto*' nextstat+3); emit (E.place ': =' '0'); emit ('*goto*' nextstat+2); emit (E.place ': =' '1');}
E → *true*	{ E.place := newtemp(); emit (E.place ':=' '1');}
E → *false*	{E.place = newtemp(); emit (E.place ':=' '0'); }

Example

Translation of a<b or c<d and e<f:

```
1.  100:  if a<b goto 103          E.place=t1;
    101:  t1 := 0
    102:  goto 104
    103:  t1 := 1
2.  104:  if c<d goto 107          E.place=t2;
    105:  t2 := 0
    106:  goto 108
    107:  t2 := 1
3.  108:  if e<f goto 111          E.place=t3;
    109:  t3 := 0
    110:  goto 112
    111:  t3 := 1
4.  112:  t4 := t2 and t3         E.place=t4;
5.  113:  t5 := t1 or t4          E.place=t5;
```

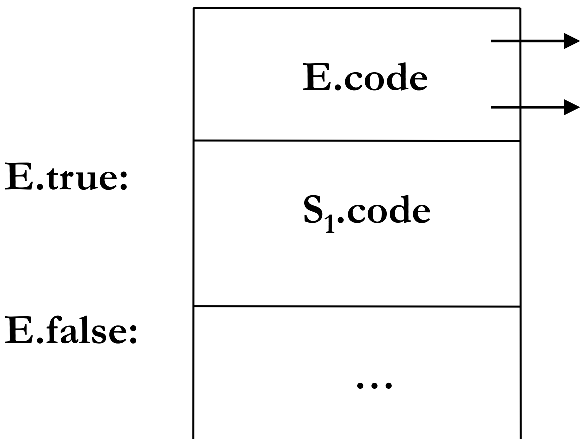
Flow of Control Statements

S → if E then S1

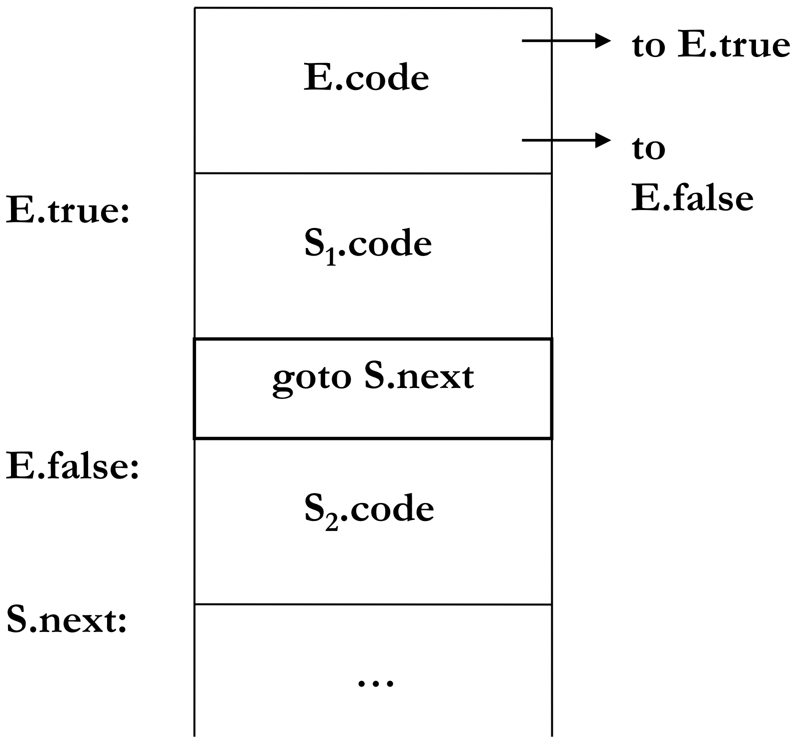
S → if E then S1 else S2

S → while E do S1

Pictorial Representation

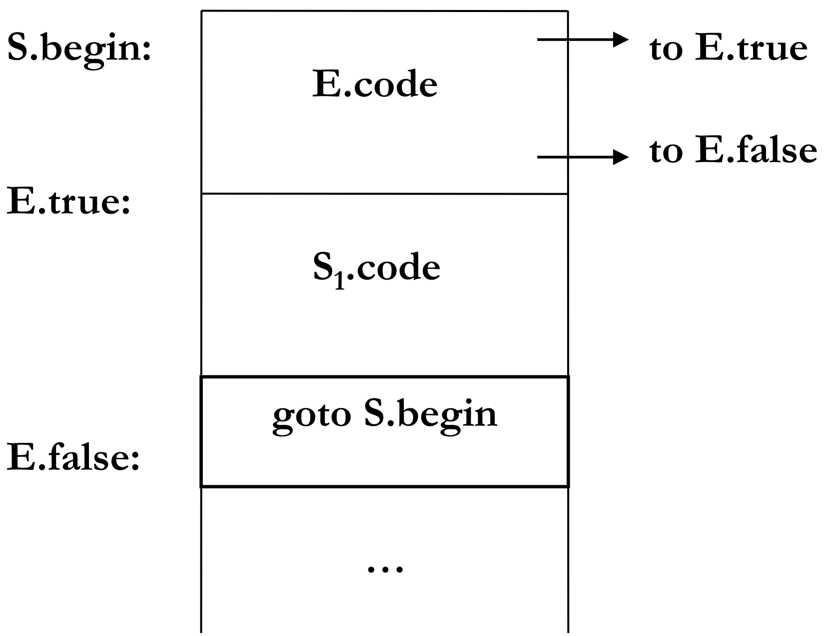


if - then



if – then - else

Pictorial Representation



while - do

Syntax directed Definition for Flow of Control Statements

S → if E then S1

{ E.true := newlabel ;

E.false := S.next ;

S1.next := S.next ;

S.code := E.code ||

gen(E.true ‘:’) || S1.code

}

Syntax directed Definition for Flow of Control Statements

S → if E then S1 else S2

{

E.true := newlabel ;

E.false := newlabel ;

S1.next := S.next ;

S2.next := S.next ;

S.code := E.code || gen(E.true ‘:’) || S1.code || gen(‘goto’ S.next) || gen(E.false ‘:’) || S2.code

}

Syntax directed Definition for Flow of Control Statements

S → while E do S1

{

S.begin := newlabel ;

E.true := newlabel ;

E.false := S.next ;

S1.next := S.begin ;

S.code := gen(S.begin ‘:’) || E.code || gen(E.true ‘:’) || S1.code || gen(‘goto’ S.begin)

}

Control Flow translation of Boolean Expression

E → E1 *or* E2	E1.True:=E.True; E1.False:=*newlabel();* E2.True:=E.True; E2.False:=E.False; E.Code:=E1.Code ||*gen*('E1.False:') || E2.Code
E → E1 *and* E2	E1.True:= *newlabel();* E1.False:=E.False; E2.True:=E.True; E2.False:=E.False; E.Code:=E1.Code ||*gen*('E1.True:') || E2.Code

Control Flow translation of Boolean Expression

E → *not* E1	E1.True:= E.False; E1.False:=E.True; E.Code:=E1.Code
E → (E1)	E1.True:= E.True; E1.False:=E.False; E.Code:=E1.Code
E → *id1 relop id2*	E.Code:= gen('*if*' id1.place relop.op id2.place '*goto*' E.True) || *gen('goto'* E.False)
E → *true*	E.Code:= *gen('goto'* E.True)
E → *false*	E.Code:= *gen('goto'* E.False);

Switch Statement Syntax

```
switch E
begin
    case V1: S1;
    case V2: S2;
    …
    case Vn-1: Sn-1;
    default : Sn;
end
```

Translation of a case statement

```
code to evaluate E
   into t
goto test
L1:    code for S1
       goto next;
L2:    code for S2
       goto next;
…
Ln-1: code for Sn-1
       goto next;
Ln:    code for Sn
       goto next;
```

```
Test:  if t=V1 goto L1
       if t=V2 goto L2
       …
       if t=Vn-1 goto Ln-1
       goto Ln
Next:
```

Another Translation of a case statement

```
code to evaluate E into t
    if t≠V1 goto L1
    code for S1
    goto next
L1:if t≠V2 goto L2
    code for S2
    goto next
L2:if t≠V3 goto L3
    code for S3
    goto next
…
Ln-1:       code for Sn
Next:
```

Summary

- Intermediate code
- Translation scheme of assignment statement
- Translation scheme of Boolean expression
- TAC – switch case statement

Check your understanding?

1. Generate three address code for the following assignment statements

   (a) x := a * b + c * d

   (b) a := b * -c + b* -c

2. Generate TAC for the following boolean expressions

   (a) x:= a < b and b > c and d < c

3.Generate TAC for the control flow statements

   (a) if a < b then

       x := y + z

   (a) if (a < b && x == y)

       { z = c * d / -f; a = f – d }

Check your understanding?

```
4. While i < 10 do
    {
        a =0;
        i = i +1;
     }
5. switch(i+j)
   {
      case 1: x=y+z; break;
      case 2: u = v + w; break;
      deault : p=q+r;
  }
```