CS322 Languages and Compiler Design II

Spring 2012

Lecture 6

INTERMEDIATE LANGUAGES

Why have one?

- Simplify compilation task by dividing into stages
- Ease porting to new source or target language
- Ease implementation of code transformations

Must bridge souce and object code styles

Source code is primarily **hierarchical**

- expressions
- structured control statements
- (perhaps) local scoping

Object code is primarily **linear**

- explicit intermediate values
- explicit labels and jumps
- flat name space

SOURCE CODE → ?? → OBJECT CODE

Intermediate language is a compromise

- maintain some hierarchy for ease of generating I.L.
- linearize somewhat for ease of generating object code
- many possibilities

Linear machine-like code

- expressions are linearized, with intermediate results in temporaries
- use explicit labels & jumps
- flat address space

I.R. trees

- expressions remain in tree form
- use explicit labels & jumps
- locally-scoped temporaries

Stack machine code

- expressions are linearized with intermediate results on stack
- use explicit labels & jumps

SPECIFYING 3-ADDRESS CODE

General form: three operands, one operator

```
X := Y op Z
```

Typical operators:

```
A := B
A := B op C
goto L
if0 A goto L
A := addr B
A := *B
```

Operands: named variables, temporaries, labels.

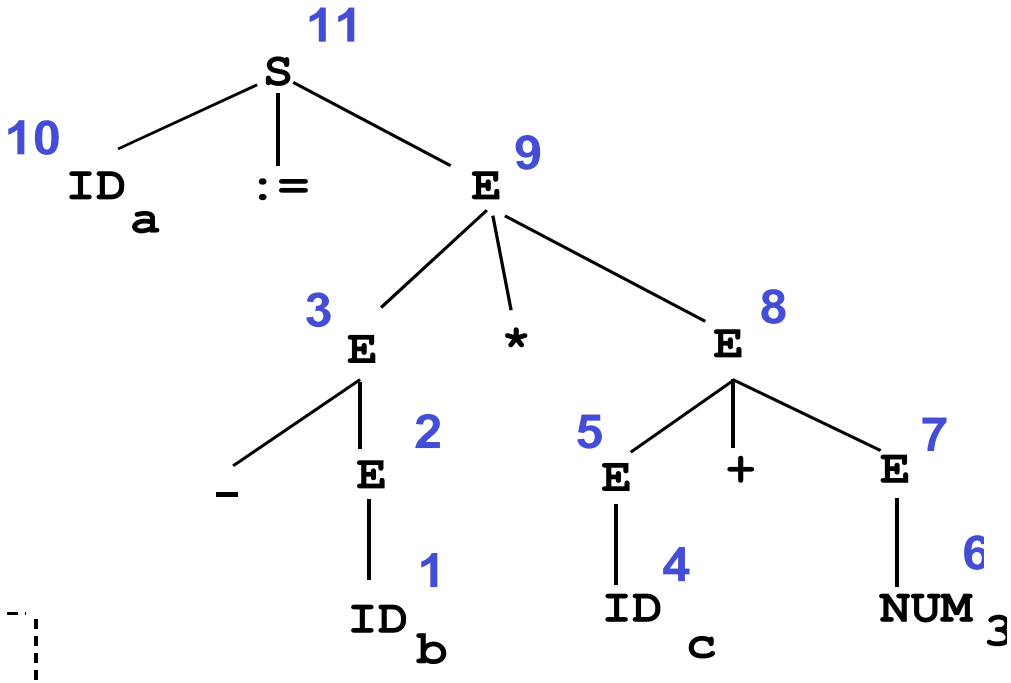
Assume an abstract instruction-generation function:

```
gen(result,operator,arg1,arg2)
```

- can produce strings, “quads,” or whatever.

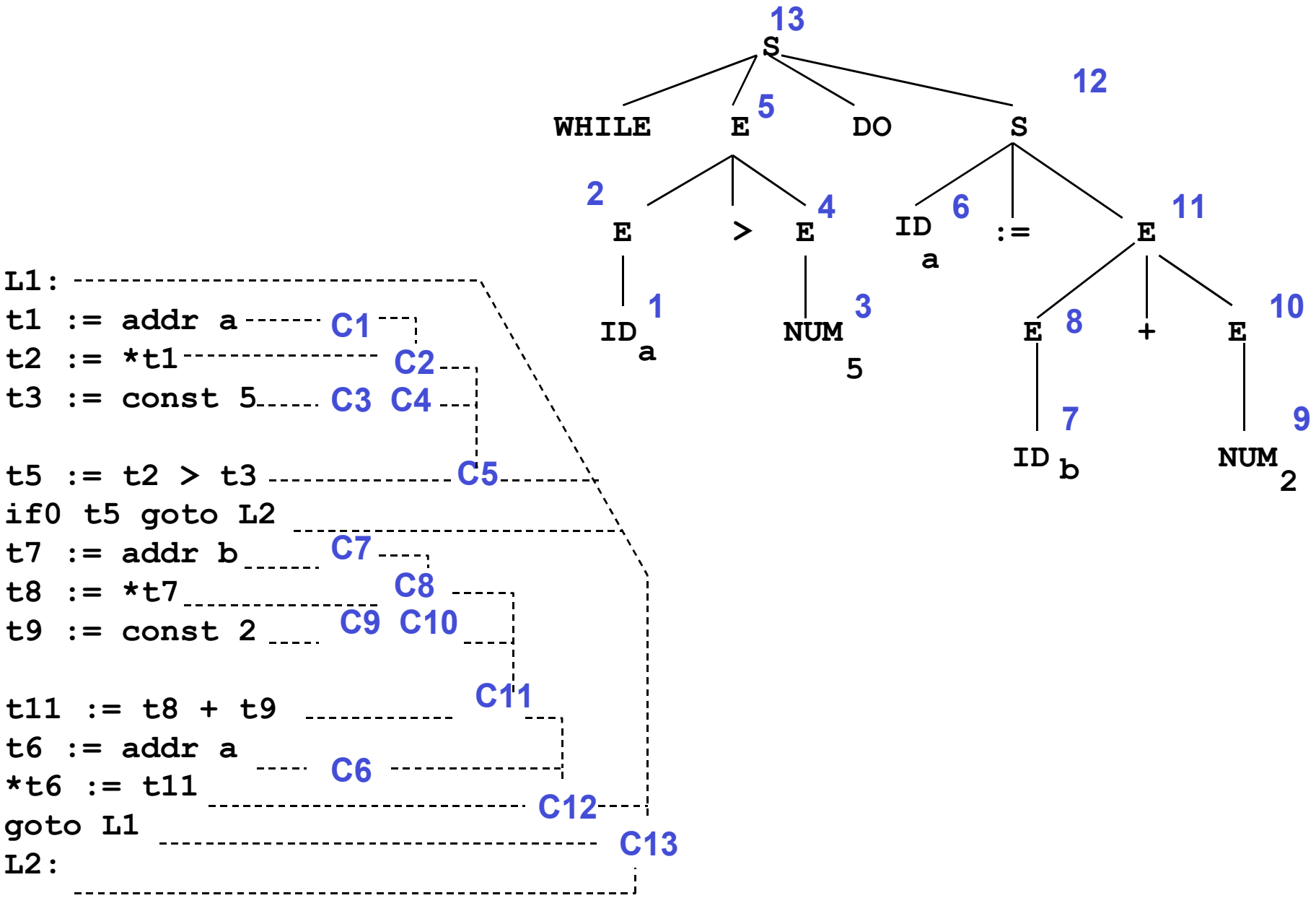
Quite ad-hoc: we’ll add new instructions when we need to.

Example: 3-Addr Code for `a := -b * (c + 3)`




```
t1  := addr b ------ C1
t2  := *t1 ---------------- C2
t3  := uminus t2 ------------ C3
t4  := addr c ------- C4
t5  := *t4 ---------------- C5
t6  := const 3 ----- C6  C7 ----
t8  := t5 + t6 ---------------- C8
t9  := t3 * t8 ---------------------- C9
t10 := addr a ----- C10 ----------------------
*t10 := t9 ------------------------------- C11
```

Example: 3-Addr Code for `while a > 5 do a := b + 2`



Syntax-directed translation of Expressions

```
E := V          E.place = newtemp();
                E.code = V.code @ [gen(E.place,*,V.place,_)]

E := N          E.place = N.place;
                E.code = N.code

E := E '+' E    E.place = newtemp();
                E.code = E1.code @ E2.code @ [gen(E.place,+,E1.place,E2.place)]

E := '-' E      E.place = newtemp();
                E.code = E1.code @ [gen(E.place,uminus,E1.place)]

E := E '>' E    E.place = newtemp();
                E.code = E1.code @ E2.code @ [gen(E.place,>,E1.place,E2.place)]

V := VAR        V.place = newtemp();
                V.code = [gen(V.place,addr,VAR.var,_)]

N := NUM        N.place = newtemp();
                N.code = [gen(N.place,const,NUM.num,_)]
```

CONTRAST: SYNTAX-DIRECTED EVALUATION OF EXPRESSIONS

```
E := V          E.val = *V.loc

E := N          E.val = N.val

E := E '+' E    E.val = E1.val + E2.val

E := '-' E      E.val = - E1.val

E := E '>' E    E.val = (E1.val > E2.val) ?  1 :  0

V := VAR        V.loc = lookup(VAR.var)

N := NUM        N.val = NUM.num
```

SYNTAX-DIRECTED TRANSLATION OF STATEMENTS

```
S := V ':=' E          S.code =  E.code @ V.code @
                                 [gen(*V.place,:=,E.place,_)]

S := S1 ';' S2         S.code =  S1.code @ S2.code

S := WHILE E DO S1     S.code =  let begin = newlabel()
                                     end = newlabel()
                                 in [gen(begin,:,_,_)] @
                                    E.code @
                                    [gen(end,if0,E.place,_)] @
                                    S1.code @
                                    [gen(begin,goto,_,_),
                                     gen(end,:,_,_)]
```

WHILE generates:

```
    L1: if0 E goto L2
        S1
        goto L1
    L2:
```

CONTRAST: SYNTAX-DIRECTED EVALUATION OF STATEMENTS

```
S := V ':=' E          exec() {update(V.loc,E.val):}

S := WHILE E DO S1     exec() {while (E.val <> 0) S1.exec();}

S := S1 ';' S2         exec() {s1.exec(); s2.exec()}
```