# Semantic actions for control structures

## Statement lists

- So far we have discussed generating code for one assignment statement
- Generating code for multiple statements is easy

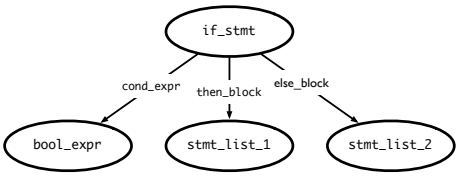
$$\texttt{stmt\_list} \rightarrow \texttt{stmt stmt\_list} \mid \lambda$$

- Keep appending (or prepending) the code generated by a single statement to the code generated by the rest of the statement list
- What if statement is not an assignment?

## If statements

```
if <bool_expr_1>
  <stmt_list_1>
else
  <stmt_list_2>
endif
```

## If statements




## Generating code for ifs

```
if <bool_expr_1>
  <stmt_list_1>
else
  <stmt_list_2>
endif
```

```
  <code for bool_expr_1>
  j<!op> ELSE_1
  <code for stmt_list_1>
  jmp OUT_1
ELSE_1:
  <code for stmt_list_2>
OUT_1:
```

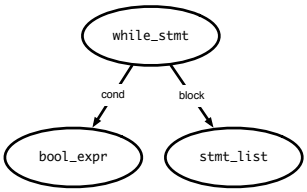
## Notes on code generation

- The <op> in j<!op> is dependent on the type of comparison you are doing in <bool_expr>
- When you generate JUMP instructions, you should also generate the appropriate LABELs
- Remember: labels have to be unique!

# Processing Loops

## While loops

```
while <bool_expr>
  <stmt_list>
endwhile
```




## Generating code for while loops

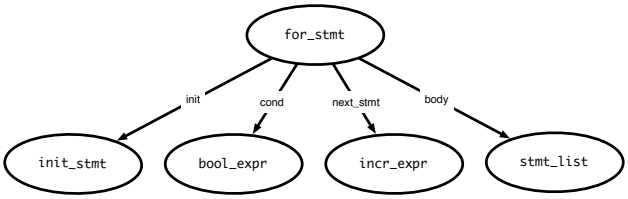
```
while <bool_expr>
  <stmt_list>
endwhile;
```

```
LOOP:
  <bool expr>
  j<!op> OUT
  <stmt_list>
  jmp LOOP
OUT:
```

- Re-evaluate expression each time
- Question: what would code for "repeat until" loop look like? For "do while"?

## For loops

```
for (<init_stmt>;<bool_expr>;<incr_stmt>)
  <stmt_list>
end
```




## Generating code: for loops

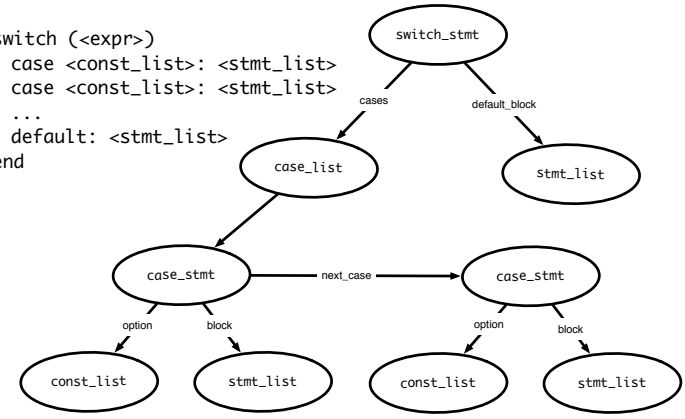
```
for (<init_stmt>;<bool_expr>;<incr_stmt>)
  <stmt_list>
end
```

```
  <init_stmt>
LOOP:
  <bool_expr>
  j<!op> OUT
  <stmt_list>
INCR:
  <incr_stmt>
  jmp LOOP
OUT:
```

- Execute init_stmt first
- Jump out of loop if bool_expr is false
- Execute incr_stmt after block, jump back to top of loop
- Question: Why do we have the INCR label?

## Switch statements

```
switch (<expr>)
  case <const_list>: <stmt_list>
  case <const_list>: <stmt_list>
  ...
  default: <stmt_list>
end
```



# Switch statements

```
switch (<expr>)
  case <const_list>: <stmt_list>
  case <const_list>: <stmt_list>
  ...
  default: <stmt_list>
end
```

- Generated code should evaluate <expr> and make sure that some case matches the result
- Question: how to decide where to jump?

# Deciding where to jump

- Problem: do not know *which label* to jump to until switch expression is evaluated
- Use a jump table: an array indexed by case values, contains address to jump to
  - If table is not full (i.e., some possible values are skipped), can point to a default clause
    - If default clause does not exist, this can point to error code
  - Problems
    - If table is sparse, wastes a lot of space
    - If many choices, table will be very large

# Jump table example

Consider the code:
((xxxx) is address of code)

Case x is
(0010) When 0: stmts
(0017) When 1: stmts
(0192) When 2: stmts
(0198) When 3 stmts;
(1000) When 5 stmts;
(1050) Else stmts;

Table only has one Unnecessary row (for choice 4)

Jump table has 6 entries:

| | |
|---|---|
| 0 | JUMP 0010 |
| 1 | JUMP 0017 |
| 2 | JUMP 0192 |
| 3 | JUMP 0198 |
| 4 | JUMP 1050 |
| 5 | JUMP 1000 |

# Jump table example

Consider the code:
((xxxx) Is address of code)

Case x is
(0010) When 0: stmts0
(0017) When 1: stmts1
(0192) When 2: stmts2
(0198) When 3 stmts3
(1000) When 987 stmts4
(1050) When others stmts5

Table only has 983 unnecessary rows. Doesn't appear to be the right thing to do! ***NOTE: table size is proportional to range of choice clauses, not number of clauses!***

Jump table has 6 entries:

| | |
|---|---|
| 0 | JUMP 0010 |
| 1 | JUMP 0017 |
| 2 | JUMP 0192 |
| 3 | JUMP 0198 |
| 4 | JUMP 1050 |
| ... | JUMP 1050 |
| 986 | JUMP 1050 |
| 987 | JUMP 1000 |

# Linear search example

Consider the code:
(xxxx) Is offset of local Code start from the Jump instruction

Case x is
(0010) When 0: stmts
(0017) When 1: stmts
(0192) When 2: stmts
(1050) When others stmts;

If there are a small number of choices, then do an in-line linear search. A straightforward way to do this is generate code analogous to an IF THEN ELSE.

If (x == 0) then stmts1;
Elseif (x = 1) then stmts2;
Elseif (x = 2) then stmts3;
Else stmts4;

O(n) time, n is the size of the table, for each jump.

# Dealing with jump tables

```
switch (<expr>)
  case <const_list>: <stmt_list>
  case <const_list>: <stmt_list>
  ...
  default: <stmt_list>
end
```

```
    <expr>
    <code for jump table>
  LABEL0:
    <stmt_list>
  LABEL1:
    <stmt_list>
  ...
  DEFAULT:
    <stmt_list>
  OUT:
```

- Generate labels, code, then build jump table
  - Put jump table after generated code
- Why do we need the OUT label?
  - In case of `break` statements