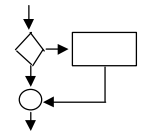
Statement-Level Control

- **Three types:**
  - **sequencing (not much to be said about this)**
  - **selection**
  - **repetition**

Selection

- **Issues:**
  - **How is selection controlled?**
  - **How many choices? Can none of the choices be selected**
- **Single-way selectors**

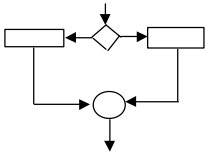


if <bool> then <stmt>

  - **Without compound statements, need GOTO**

Two-Way Selection

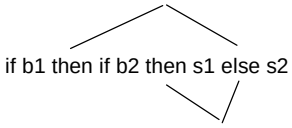
- **Two-way selectors**



if <bool> then <stmt> else <stmt>

Dangling Elses

- **Recall potential ambiguity with nested 2-way selectors:**



➥ **Several possible remedies. . .**

Avoiding Ambiguity

- **Disallow nested conditionals**

<stmt> --> <a_stmt> | <if_stmt> | <c_stmt>

<c_stmt> --> begin <stmt_list> end

<if_stmt> --> if <bool> then < s_stmt>

| if <bool> then <s_stmt> else <stmt>

<s_stmt> --> <a_stmt> | <c_stmt>

```
if b1 then
        begin if b2 then s1 else s2 end

if b1 then
        begin if b2 then s1 end
                else s2
```


Multiple-Way Selection

- **Multiple-way Selection**
  - **New issues:**

    How to handle unrepresented selector values?

    Should selectable segments be followed by implicit branches out of construct?

  - **Lots of forms of multiple selectors. . .**

Multiple-Way Selection -- Early Approaches

- **Three-way selectors (Fortran)**

  IF (<arith_exp>) L1, L2, L3

  - **Must jump out of segment:**

```
        IF (...) 10, 20, 30
10      ...
        GO TO 40
20      ...
        GO TO 40
30      ...
40      ...
```

- **Computed GO TO (Fortran)**

  GO TO (L1, L2, ..., Ln), exp

  - **goes to first label if exp=1, second if exp=2, etc.**
  - **if exp < 1 or exp > n, no effect**
  - **must still jump out of segment**

Multiple-Way Selection -- Modern Approaches

- **Pascal example**

```
case <exp> of
    <const_list> : <stmt>
    ...
    <const_list> : <stmt>
end
```

  - **<exp> of ordinal type**
  - **implicit branch to end after each segment**
  - **"otherwise" option**
  - **selector value unrepresented => error**

More Modern Approaches

- **C example**

```
switch (<exp>)
{
case <const_exp> : <stmt>
 ...
case <const_exp> : <stmt>
[default : <stmt>]
}
```

  - **<exp> and <const_exp> yield integers**
  - **No implicit branches -- use "break" to leave switch**

    Is this a good idea?

- **Elsif (Ada)**
  - **Like LISP cond**
  - **Cuts down on indenting**
  - **More flexible than case statement**

Repetition

- **Iteration (statement-level)**
- **Recursion (unit-level) -- later**
- **Issues:**
  - **How is iteration controlled?**
  - **Where in loop is control mechanism?**

    top

    bottom

    anywhere

Counter-Controlled Loops

- **Issues:**
  - **Type and scope of loop variable**
  - **Value of loop variable at loop term**
  - **Change loop parameterss in body? Effect?**
  - **Branch into loop?**
  - **Test at top or bottom?**
  - **Loop parameters evaluated when?**

FORTRAN loops

- **DO <label> <var> = <init>,<term>**
  - **Can't change loop variable/parameters inside loop**
  - **Loop variable undefined after normal termination; last value if jump out**
  - **Can jump out of, back into loop**

```
DO 100 I = 1,10
...
100  CONTINUE
```

  - **Note!**

```
DO 100 I = 1.10
```

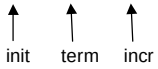
More Loop Examples

- **ALGOL 60**
  - **Very complicated! see book.**
- **ALGOL 68**

  for i from j by k to m

  while b do . . . od
- **C**

  for (<exp>;<exp>;<exp>) <stmt>


```
for (i = 0; i <= 10; i++)
    sum = sum + a[i];
```

  - **No special loop variables.**
  - **Can have multiple statements for each <exp>**

Logically Controlled Loops

- **Issues:**
  - **Pretest or posttest?**
  - **Jump into loop?**
- **Pascal constructs**

  while <exp> do <stmt>

  repeat <stmt> until <exp>

More Statement-Level Control Constructs

- **Explicit loop exits**
  - **Basic model: (Modula)**

    loop

    . . .

    if . . . then EXIT

    . . .

    end

- **Multi-level exits (Ada)**
  - **named loops**
  - **conditional EXIT**

    exit [<loop name>] [when <condition>]

Ada Example

```
Outer_loop:
    for i in 1. .10 loop
    Inner_loop:
        for j in 1. .20 loop;
            ...
            EXIT Outer_loop when <cond>;
            ...
    end loop Inner_loop;
        ...
end loop Outer_loop;
```

Iterators (Clu)

- **Lets user specify range of values over which a loop iterates.**

```
for atom:node in list(x) do
    ...

list = iter(z: linked_list) yields (node)
    ...
    yield (n)
    ...
end list
```

  - **list produces elements of type node one at a time**

Guarded Commands

```
if   <bool> -> <stmt>
□  <bool> -> <stmt>
    ...
□   <bool> -> <stmt>
fi
```

- **Semantics**
  - **Evaluate all <bool>s**
  - **If ³ 1 is true, choose one nondeterministically and execute its <stmt>**
  - **If none true, error**

Guarded Commands (continued)

```
do   <bool> -> <stmt>
□  <bool> -> <stmt>
   ...
□  <bool> -> <stmt>
od
```

- **Semantics**
  - **Evaluate all <bool>s**
  - **If ³ 1 is true, choose one nondeterministically and execute its <stmt>**
  - **Repeat until none true, then normal termination**