Structured Programming

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Lecture 7

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Program Control

- Standard C Statements

Outline

- This Topic Introduces
  - selection structure
    - **`if`**
    - **`if/else`**
  - repetition control structures
    - **`While`**
  - additional repetition control structures
    - **`for`**
    - **`do/while`**
  - **`switch`** additional multiple selection structure
  - **`break`** statement
    - Used for exiting immediately and rapidly from certain control structures
  - **`continue`** statement
    - Used for skipping the remainder of the body of a repetition structure and proceeding with the next iteration of the loop

Switch statement

- Used to select one of several alternatives
- BASED on the value of a single variable.
- This variable may be an int or a char but NOT a float (or double).

switch statement

```
// multiple selection
switch  ( integral expression )
{
case constant integral expression1:
    statements1        // expression1 matches
    break;
case constant integral expression2:
    statements2        // expression2 matches
    break;
case constant integral expression3:
    statements3        // expression3 matches
    break;
default:               // no expression matches
    statements4
    break;
}
```

Example

```
char grade ;
printf("Enter your letter grade: ");
scanf("%c", &grade);
switch ( grade )
{
  case 'A' : printf(" Excellent Job");
             break;
  case 'B' : printf ( " Very Good ");
             break;
  case 'C' : printf(" Not bad ");
             break;
  case 'F' : printf("Failing");
             break;
  default : printf(" Wrong Input ");
}
```

Light bulbs

Write a program to ask the user for the brightness of a light bulb (in Watts), and print out the expected lifetime:

Brightness	Lifetime in hours
25	2500
40, 60	1000
75, 100	750
otherwise	0

```
int bright ;
printf("Enter the bulb brightness: ");
scanf("%d", &bright);
switch ( bright )
{
  case 25 : printf(" Expected Lifetime is 2500 hours");
            break;
  case 40 :
  case 60 : printf ( "Expected Lifetime is 1000 hours  ");
            break;
  case 75 :
  case 100 : printf("Expected Lifetime is 750 hours ");
             break;
  default : printf("Wrong Input ");
}
```

break vs return

- break means exit the switch statement and continue on with the rest of the program.
- return means exit the whole program.
- They could both be used anywhere in the program.

Testing Selection Control Structures

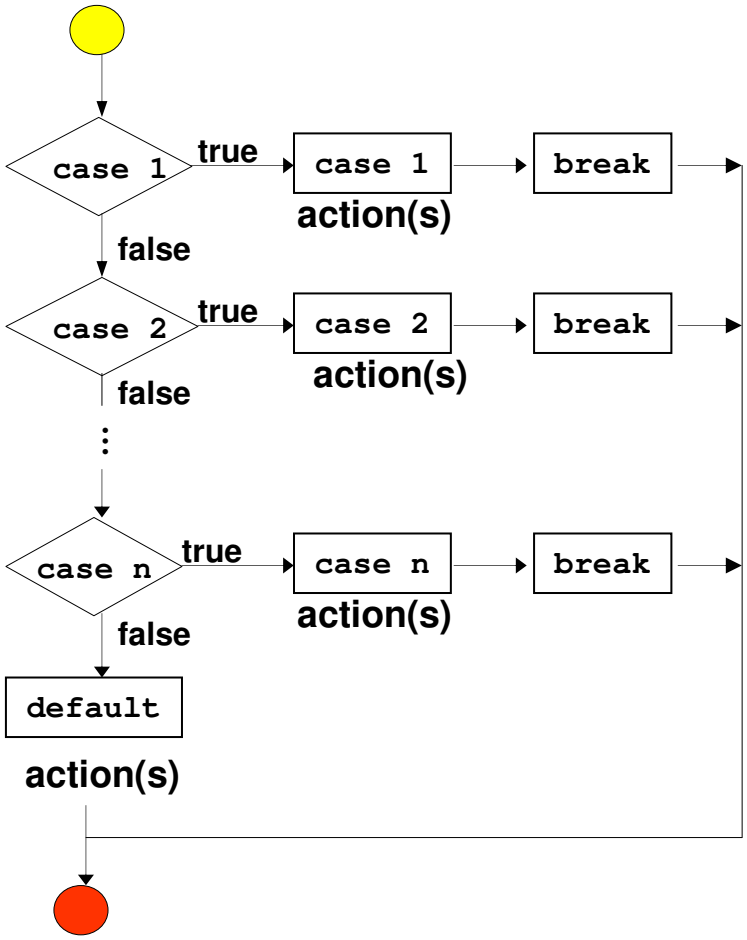
- **to test a program with branches, use enough data sets so that every branch is executed at least once**
- **this is called minimum complete coverage**

Multiple-Selection Structure: `switch`

- **`switch`**
  - Useful when a variable or expression is tested for all the values it can assume and different actions are taken
- Format
  - Series of **`case`** labels and an optional **`default`** case

```
switch ( value ){
    case '1':
        actions
    case '2':
        actions
    default:
        actions
    }
```

  - **`break;`** exits from structure
- Flowchart of the **`switch`** structure



```c
/* Fig. 4.7: fig04_07.c
 Counting letter grades */
#include <stdio.h>

int main()
{
 int grade;
 int aCount = 0, bCount = 0, cCount = 0, dCount = 0,
                 fCount = 0;

   printf(  "Enter the letter grades.\n"  );
   printf(  "Enter the EOF character to end input.\n"  );

   while ( ( grade = getchar() ) != EOF ) {

      switch ( grade ) {    /* switch nested in while */

         case 'A': case 'a':  /* grade was uppercase A */
            ++aCount;         /* or lowercase a */
            break;

         case 'B': case 'b':  /* grade was uppercase B */
            ++bCount;         /* or lowercase b */
            break;

         case 'C': case 'c':  /* grade was uppercase C */
            ++cCount;         /* or lowercase c */
            break;

         case 'D': case 'd':  /* grade was uppercase D */
            ++dCount;         /* or lowercase d */
            break;

         case 'F': case 'f':  /* grade was uppercase F */
            ++fCount;         /* or lowercase f */
            break;

```

1. **Initialize variables**
2. **Input data**
3. **Use switch loop to update count**

```
38          case '\n': case' ':  /* ignore these in input */
39             break;
40
41          default:        /* catch all other characters */
42             printf( "Incorrect letter grade entered." );
43             printf( " Enter a new grade.\n" );
44             break;
45       }
46    }
47
48    printf( "\nTotals for each letter grade are:\n" );
49    printf( "A: %d\n", aCount );
50    printf( "B: %d\n", bCount );
51    printf( "C: %d\n", cCount );
52    printf( "D: %d\n", dCount );
53    printf( "F: %d\n", fCount );
54
55    return 0;
56 }
```

4. Print results

Program Output:

```
Enter the letter grades.
Enter the EOF character to end input.
A
B
C
C
A
D
F
C
E
Incorrect letter grade entered. Enter a new grade.
D
A
B

Totals for each letter grade are:
A: 3
B: 2
C: 3
D: 2
F: 1
```

The `break` and `continue` Statements

- **`break`**
  - Causes immediate exit from a **`while`**, **`for`**, **`do/while`** or **`switch`** structure
  - Program execution continues with the first statement after the structure
  - Common uses of the **`break`** statement
    - Escape early from a loop
    - Skip the remainder of a **`switch`** structure
- **`continue`**
  - Skips the remaining statements in the body of a **`while`**, **`for`** or **`do/while`** structure
    - Proceeds with the next iteration of the loop
  - **`while`** and **`do/while`**
    - Loop-continuation test is evaluated immediately after the **`continue`** statement is executed
  - **`for`**
    - Increment expression is executed, then the loop-continuation test is evaluated

`continue` Statement

```
        while (expr) {
          statement
          …
          continue;
skip      statement
          …
        }
```

```
        do {
        statement
            …
            continue;
skip        statement
            …
        } while(expr)
```

```
for (expr1; expr2; expr3) {
    statement
    …
    continue;
    statement skip
    …
}
```

break Statement

```
while (expr) {
  statement;
  …
  if (expr)
   break;
  statements;
}
statement;
…
```

```
for (expr1; expr2; expr3)
{  statement
   …
   if (expr)
         break;
   statements;
}
statements;
```

```
switch (i) {
   case 1:
         statement_1;
   case 2:
         statement_2;
   case 3:
         statement_3;
         break;
   case 4:
         statement_4;
   }
statements;
```

Equality (==) vs. Assignment (=) Operators

- Dangerous error
  - Does not ordinarily cause syntax errors
  - Any expression that produces a value can be used in control structures
  - Nonzero values are **`true`**, zero values are **`false`**

    Example: using **`==`**:

    ```
    if ( payCode == 4 )
       printf( "You get a bonus!\n" );
    ```

    - Checks **`paycode`**, if it is **`4`** then a bonus is awarded

    Example: replacing **`==`** with **`=`**:

    ```
    if ( payCode = 4 )
       printf( "You get a bonus!\n" );
    ```

    - This sets **`paycode`** to **`4`**
    - **`4`** is nonzero, so expression is **`true`**, and bonus awarded no matter what the **`paycode`** was
  - Logic error, not a syntax error

Examples

Ex_1:

```
  if (i=1) y = 3;
```

⇒ y = 3 is always executed
this is not the same as

```
  if (i==1) y = 3;
```

Ex_2:

```
  if (i!=0) y=3;
```

⇒ `if (i) y=3;`

Ex_3:

```
if (i==0) y=3;
```

⇒ `if (!i) y=3;`

Examples:

```
Ex_1:
if (i>2)
    if (j==3)
        y=4;
    else
      y=5;
```

≠

```
if (i>2) {
    if (j==3)
        y=4;
}
else
    y=5;
```

=

```
if (i>2)
    if (j==3)
        y=4;
    else
        ;
else
        y=5;
```

```
Ex_2:
```

```
if (a>b)
      c = a;
else
      c = b;
```

⇒ `c=(a>b)?a:b`

```
if (x==5)
     y = 1;
else
     y = 0;
```

⇒ `y = (x==5);`

```
if (x<6)
    y = 1;
else
    y = 2;
```

⇒ `y = 2-(x<6);`

⇒ `or y = 1+(x>=6);`

The Essentials of Repetition

- Loop
  - Group of instructions computer executes repeatedly while some condition remains **`true`**
- Counter-controlled repetition
  - Definite repetition: know how many times loop will execute
  - Control variable used to count repetitions
- Sentinel-controlled repetition
  - Indefinite repetition
  - Used when number of repetitions not known
  - Sentinel value indicates "end of data“

Essentials of Counter-Controlled Repetition

- Counter-controlled repetition requires
  - The name of a control variable (or loop counter)
  - The initial value of the control variable
  - A condition that tests for the final value of the control variable (i.e., whether looping should continue)
  - An increment (or decrement) by which the control variable is modified each time through the loop

  Example:

```
int counter = 1;                /* initialization */
while ( counter <= 10 ) {       /* repetition condition */
   printf( "%d\n", counter );
   ++counter;                   /* increment */
}
```

  - The statement

```
int counter = 1;
```

    - Names **counter**
    - Declares it to be an integer
    - Reserves space for it in memory
    - Sets it to an initial value of **1**
    - This is ***not*** an executable statement, it is a declaration.

Repetition Structure: `while`

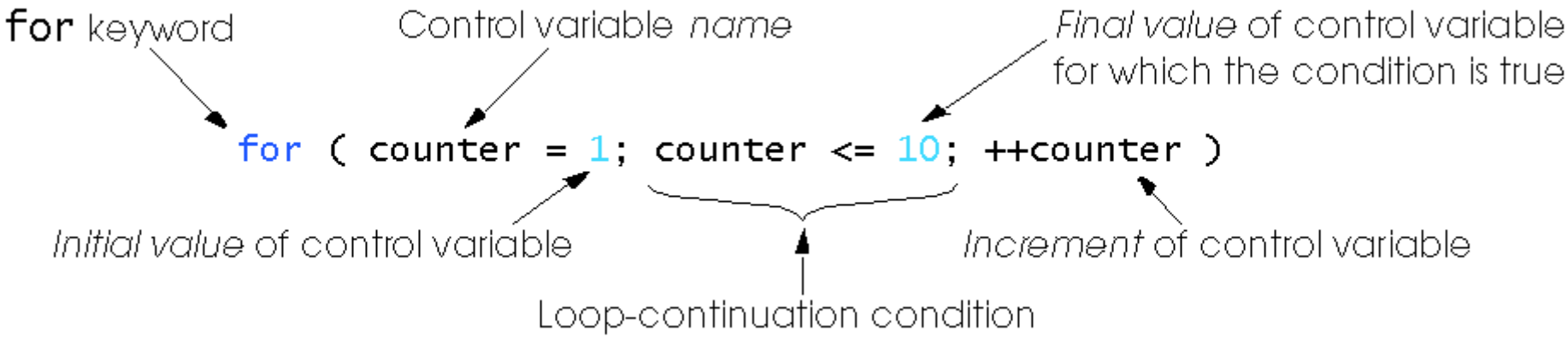
```c
/* Fig. 3.6: fig03_06.c
   Class average program with
   counter-controlled repetition */
#include <stdio.h>

int main()
{
 int counter, grade, total, average;

   /* initialization phase */
   total = 0;
   counter = 1;

   /* processing phase */
   while ( counter <= 10 ) {
      printf( "Enter grade: " );
      scanf( "%d", &grade );
      total = total + grade;
      counter = counter + 1;
   }
average = ( float ) total / counter;
   /* termination phase */
   printf( "Class average is %d\n", average );

   return 0;   /* indicate program ended successfully */
}
```

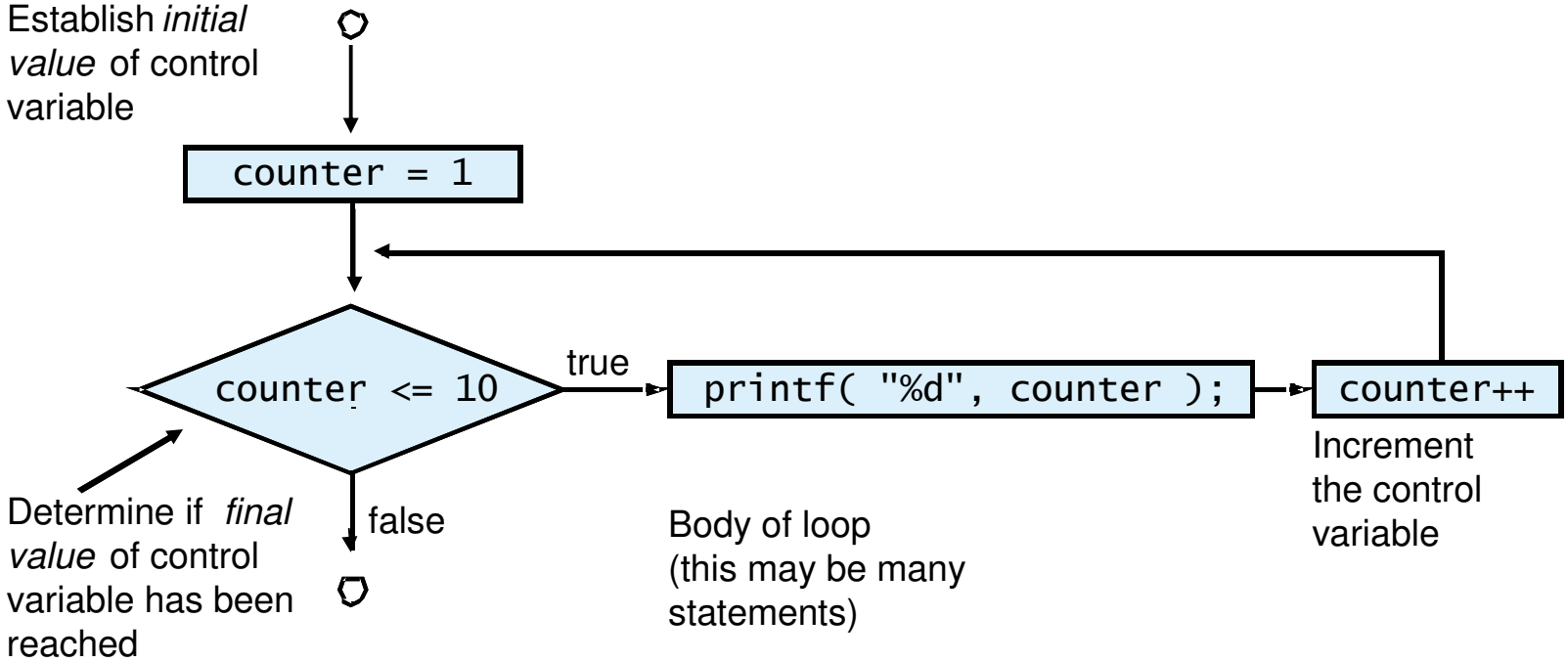
```c
printf( "Enter grade, -1 to end: " );
scanf( "%d", &grade );
while ( grade != -1 ) {
   total = total + grade;
   counter = counter + 1;
   printf( "Enter grade, -1 to end: " );
   scanf( "%d", &grade );
}    /* termination phase */
if ( counter != 0 ) {
   average = ( float ) total / counter;
   printf( "Class average is %.2f", average );
}
else
   printf( "No grades were entered\n" );
```

Program Output:

```
Enter grade: 98
Enter grade: 76
Enter grade: 71
Enter grade: 87
Enter grade: 83
Enter grade: 90
Enter grade: 57
Enter grade: 79
Enter grade: 82
Enter grade: 94
Class average is 81
```

4.4 The `for` Repetition Statement





Repetition Structure: `for`

- `for` loops syntax

  for (initialization ; loopContinuationTest ; increment)
  statement

  Example: Prints the integers from one to ten

```
for ( counter = 1; counter <= 10; counter++ )
  printf( "%d\n", counter );
```

- For loops can usually be rewritten as `while` loops:

```
initialization;
while ( loopContinuationTest ) {
  statement;
  increment;
}
```

No semicolon `(;)` after last expression

- Initialization and increment
  - Can be comma-separated list of statements

    Example:

```
for ( i = 0, j = 0;  j + i <= 10; j++, i++)
   printf( "%d\n", j + i );
```

The `for` Structure (cont.)

- Arithmetic expressions
  - Initialization, loop-continuation, and increment can contain arithmetic expressions. If **`x`** equals **`2`** and **`y`** equals **`10`**

```
for ( j = x; j <= 4 * x * y; j += y / x )
```

is equivalent to

```
for ( j = 2; j <= 80; j += 5 )
```

- Notes about the **`for`** structure:
  - "Increment" may be negative (decrement)
  - If the loop continuation condition is initially **`false`**
    - The body of the **`for`** structure is not performed (i.e. pre-test)
    - Control proceeds with the next statement after the **`for`** structure
  - Control variable
    - Often printed or used inside for body, but not necessarily

The `for` Structure (cont.)

```
1  /* Fig. 4.5: fig04_05.c
2     Summation with for */
3  #include <stdio.h>
4
5  int main()
6  {
7     int sum = 0, number;
8
9     for ( number = 2; number <= 100; number += 2 )
10       sum += number;
11
12    printf( "Sum is %d\n", sum );
13
14    return 0;
15 }
```

1. **Initialize variables**
2. **`for` repetition structure**

Program Output:

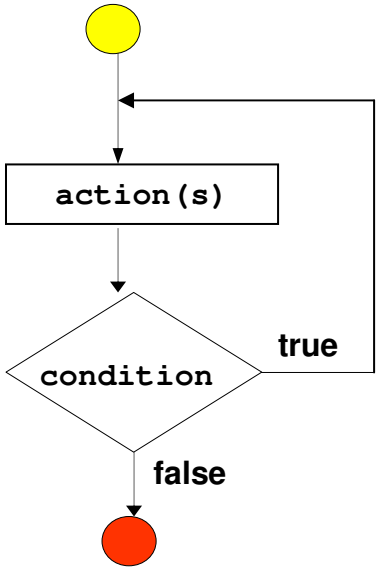
```
Sum is 2550
```

2 + 4 + 8 + … +100 = 2550

Repetition Structure: `do/while`

- The **`do/while`** repetition structure
  - Similar to the **`while`** structure
  - do/while is a "post-test" condition. The body of the loop is performed at least once.
    - All actions are performed at least once
  - Format:

```
do {
    statement;
} while ( condition );
```



Example: Prints the integers from **`1`** to **`10`**.

(letting counter = 1):

```
do {
    printf( "%d  ", counter );
} while (++counter <= 10);
```

- Flowchart of the **`do/while`** repetition structure

Repetition Structure: do/while

```
1  /* Fig. 4.9: fig04_09.c
2     Using the do/while repetition structure */
3  #include <stdio.h>
4
5  int main()
6  {
7     int counter = 1;
8
9     do {
10       printf( "%d  ", counter );
11    } while ( ++counter <= 10 );
12
13    return 0;
14 }
```

1. Initialize variable
2. Loop
3. Print

Program Output:

```
1  2  3  4  5  6  7  8  9  10
```