System SW

Lecture 6 – Basics of C programming language – Part 5

Jarno Tuominen / Reviewed by Sanna Määttä

Lecture 8 – Basics of C programming language – Part 5

- Review
- Loop statements
- Functions

Review of last lecture

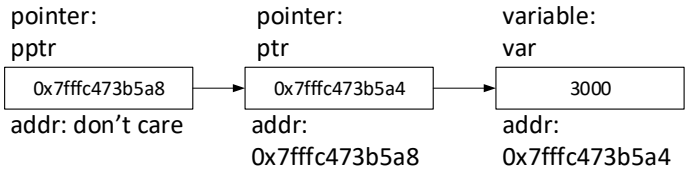
- Pointers (cont)
- C operators
- Conditional execution

Review: Pointers

- Coding rules
  - Initialize to NULL to enable testing of unitilzaed pointer
  - Use some meaningful prefix/suffix for pointer variables to prevent accidental misuse of pointer variables
- NULL pointers
  - Can be used to check if malloc() succedded
  - Can indicate end of linked list
- Void pointers
  - Used to implement general functions, which support multiple data types as arguments or as return values
  - Can be type casted to any type
- Pointer arithmetics
  - 4 artihmetic ops: ++, --, +, -
  - Comparison possible
  - Arithmetic according to data type of a pointer
- Pointers to pointers
  - ** indicates double indirection

```
// pointer to an integer, initialized to NULL
int * i_p = NULL;

if(i_p) {"not NULL, move on"}
if(!i_p) {"error, do something"}
```

```
int *x_p = malloc(32);
if(!i_p) {"memory allocation failed! "}
```




```
var = *ptr = **pptr
```

Review: C operators

Type	Operators
Logical	||, &&, !
Bitwise	<<, >>, |, &, ^, ~
Arithmetic	+, -, /, *, ++, --, %
Relational	<, <=, >, =>, ==, !=

```
|| = logical OR
&& = logical AND
!  = logical NOT
```

```
<< = Left Shift
>> = Right Shift
| = Bitwise OR
& = Bitwise AND
^ = Bitwise XOR
~ = One's Complement
```

```
+  = Addition
-  = Subtraction
/  = Divide
*  = Multiply
++ = Increment
-- = Decrement
%  = Modulus
```

```
<  = Less-Than
<= = Less-Than Or Equal to
>  = Greater-Than
>= = Greater-Than or Equal to
== = Equal to
!= = Not Equal To
```

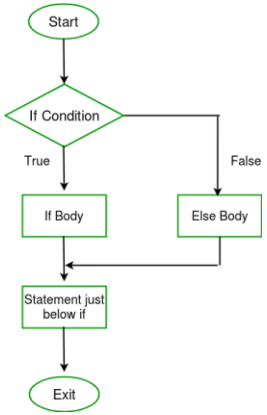
Review: Compound operators and ?:

Addition assignment	a += b	a = a + b
Subtraction assignment	a -= b	a = a - b
Multiplication assignment	a *= b	a = a * b
Division assignment	a /= b	a = a / b
Modulo assignment	a %= b	a = a % b
Bitwise AND assignment	a &= b	a = a & b
Bitwise OR assignment	a |= b	a = a | b
Bitwise XOR assignment	a ^= b	a = a ^ b
Bitwise left shift assignment	a <<= b	a = a << b
Bitwise right shift assignment	a >>= b	a = a >> b

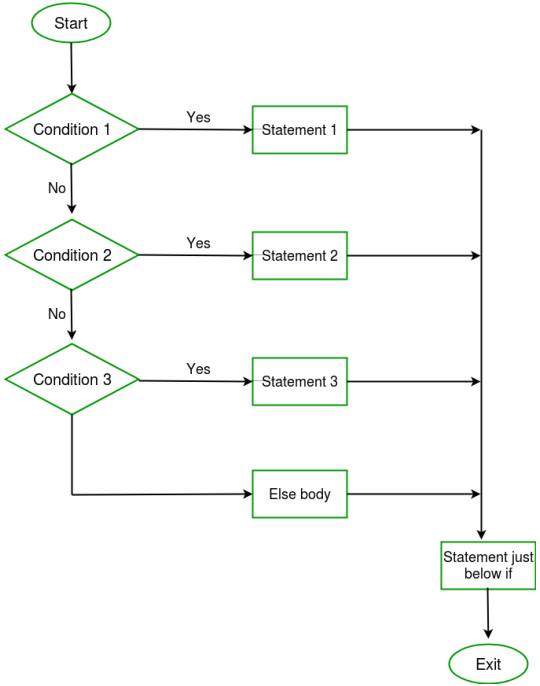
```
res = (a > b) ? x : y;

evaluates to

if (a>b) {
        res = x;
} else {
        res = y;
}
```

Review: Conditional execution

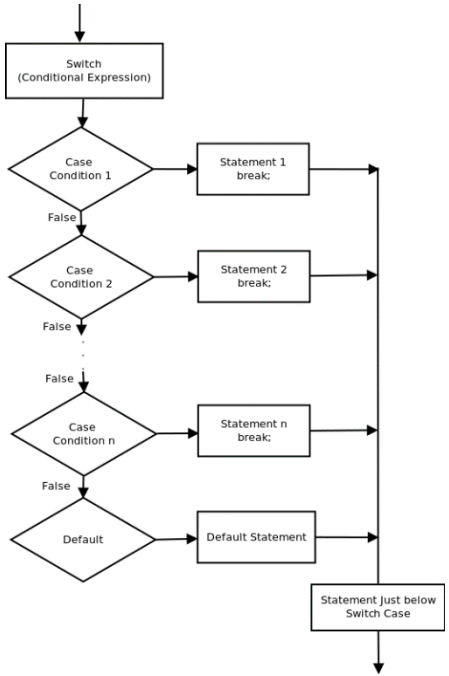
if-else



if-else if -ladder



switch-case

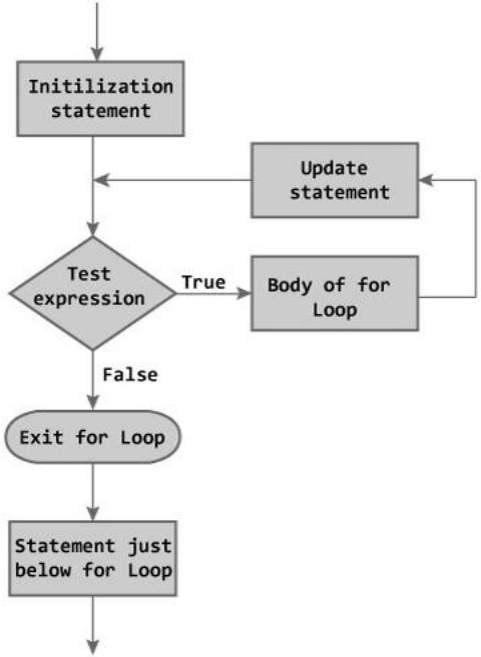


Lecture 8 – Basics of C programming language – Part 5

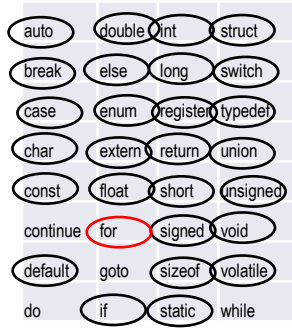
- Review
- Loop statements
- Functions

For - loops

- A block of code is repeated based on condition expression
  - Preloop condition check
- Loop counter can be declared and initialized at the for-loop statement

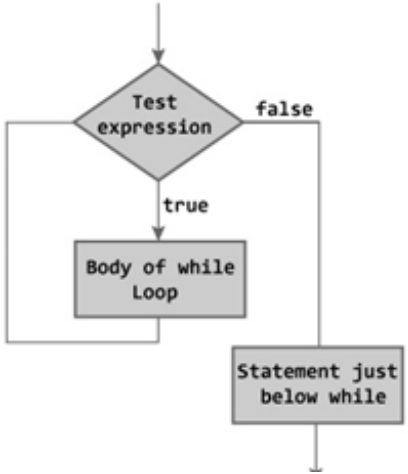



```c
#include <stdio.h>
int main()
{
   int sum = 0;
   int num = 10;

   for(int count = 1; count <= num; count++) {
      sum += count;
   }
   printf("Sum = %d", sum);
   return 0;
}
```

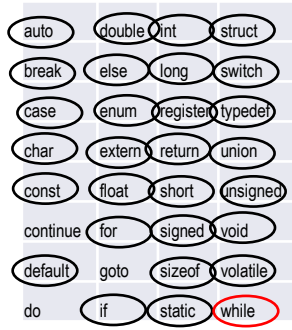


While - loops

- A block of code (body of while loop) is repeated based on condition check
- Preloop condition check: executed zero or more times



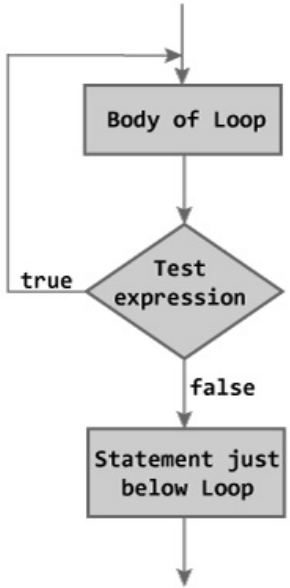

```
int number = 10;
int factorial = 1;

// loop terminates when number is less than or equal to 0
while (number > 0) {
  factorial *= number;  // factorial = factorial*number;
  number--;
}
printf("Factorial= %lld", factorial);
```

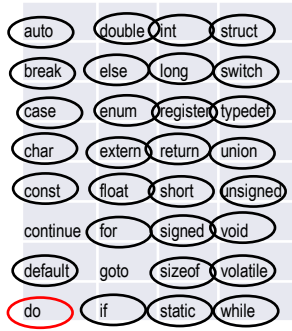


Do – While Loops

- A block of code (body of while loop) is repeated based on condition check
- Postloop condition check: executed **at least once**

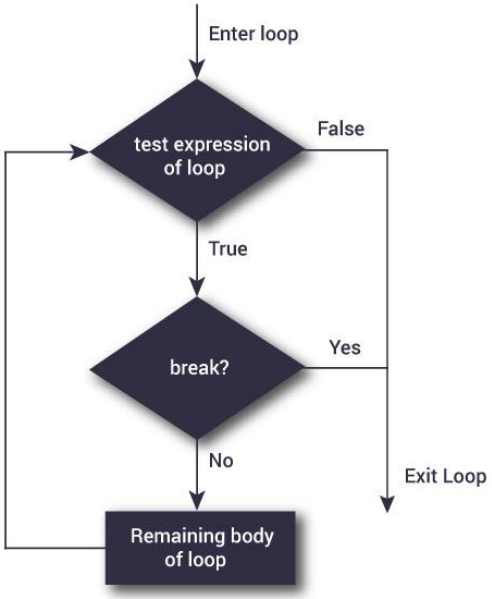
```
int number, sum = 0;

// loop body is executed at least once
do {
  printf("Enter a number: ");
  scanf("%d", &number);
  sum += number;
  } while(number != 0);

printf("Sum = %d",sum);
```





break in loops

- **break** causes exit from the loop
- In case of nested loops, exits only the inner loop

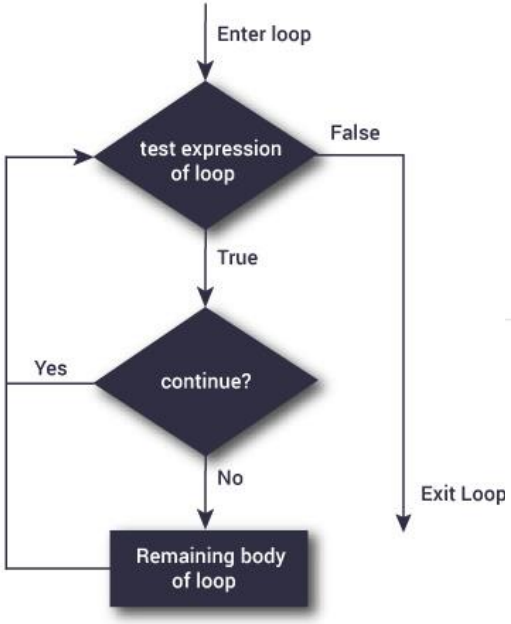



```
while (test Expression)
{
    // codes
    if (condition for break)
    {
        break;
    }
    // codes
}
```

```
for (init, condition, update)
{
    // codes
    if (condition for break)
    {
        break;
    }
    // codes
}
```

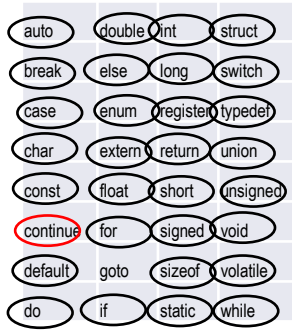
continue in loops

- **continue** stops the current iteration and moves to next iteration (and checks the condition)




```
while (test Expression)
{
    // codes
    if (condition for continue)
    {
        continue;
    }
    // codes
}
```

```
for (init, condition, update)
{
    // codes
    if (condition for continue)
    {
        continue;
    }
    // codes
}
```



goto – for a spaghetti code

- "goto" allows you to jump unconditionally to arbitrary part of your code (within the same function)
  - the location is identified using a label
  - a label is a named location in the code. It has the same form as a variable followed by a ':'
- Generally, avoid using goto
  - Dijkstra: Go To Statement Considered Harmful. Communications of the ACM 11(3),1968
  - Excess use of goto creates spaghetti code
  - Using goto makes code harder to read and debug
  - Any code that uses goto can be written without using one

```
start:
{
    if (cond )
        goto outside;
    /* some code here */
    goto start;
}
outside:
```

goto – ok, for error handling

- Languages like C++ and Java provide exception mechanism to recover from errors. In C, goto provides a convenient way to exit from nested blocks.

```
for (..) {
      for (..) {
            if (error_cond)
                  goto error; /* skips 2 blocks */
      }
}
error:
```

```
cont_flag=1;
for (..) {
      for (init; cont_flag ;iter) {
            if (error_cond) {
                  cont_flag =0;
            }
            //inner loop
      }
      if (!cont_flag) break;
      //outer loop
}
```

Lecture 8 – Basics of C programming language – Part 5

- Review
- Loop statements
- Functions

Function declaration / prototype

- A C program must have at least one function: main(), which is the only one not requiring the declaration
- A function **declaration** tells the compiler about a function's name, return type, and parameters.
  - A function needs to be declared before usage
  - Declarations/protypes typically in .h –file
  - Specifies the type, unique name and parameter list of a function
  - Not needed if the function is before the calling function, in a same .c-file.
  - Parameter names are not important in function declaration only their type is required…

```
return_type function_name( parameter list );
```

```
int max(int num1, int num2);
```

```
int max(int, int);
```

… **but it is good programming Policy to also name the parameters**

Function definition

- A function **definition** provides the actual body of the function
  - Return data type and parameters data types must match the function prototype
  - Return value can be of any data type, even a pointer – or nothing (**void**)
  - A function may be distributed as a part of a library (even encrypted) – in this case the prototype is still required.

```
return_type function_name( parameter list ) {
   body of the function
}
```

```
/* function returning the max between two
numbers */
int max(int num1, int num2) {

   /* local variable declaration */
   int result;

   if (num1 > num2)
      result = num1;
   else
      result = num2;

   return result;
}
```

Static functions

- By default, all the functions are global – they have ”extern” storage class
- In order to suppress the visibility of function to a module (file) scope, use static
- This prevents the usage of the function from the external modules
  - decreases the coupling between your modules
  - helps maintain your software architecture and reduces bugs

RULE: The static keyword shall be used to declare all functions and variables that do not need to be visible outside of the module in which they are declared.
(Barr: C coding standard 2018)

File: clkgen.c

```
static void clk_high() {
    set_io(PIN_NUMBER);
}

static void clk_low() {
    clear_io(PIN_NUMBER);
}

void create_8clocks() {
    for (uint8_t i=0; i<8; i++) {
        clk_high();
        delay_us(10);
        clk_low();
        delay_us(10);
    }
}
```

“private” functions

Calling a function

- When a program calls a function, the program control is transferred to the called function
- A called function performs a defined task and when its return statement is executed or when its function-ending closing brace is reached, it returns the program control back to the main program
- To call a function, you simply need to pass the required parameters along with the function name, and if the function returns a value, then you can store the returned value

```c
#include <stdio.h>
/* function declaration */
int max(int num1, int num2);

int main () {
   /* local variable definition */
   int a = 100;
   int b = 200;
   int ret;
   /* calling a function to get max value */
   ret = max(a, b);
   printf( "Max value is : %d\n", ret );
    return 0;
}
```

```c
/* function returning the max of two numbers */
int max(int num1, int num2) {

   /* local variable declaration */
   int result;

   if (num1 > num2)
      result = num1;
   else
      result = num2;

   return result;
}
```

Passing function arguments

- The parameters (or arguments) of a function, that are given in function call are **actual parameters**
- The parameters listed in function declaration are **formal parameters**
- Formal parameters behave like other **local** variables inside the function and are created upon entry into the function and destroyed upon exit
- While calling a function, there are two ways in which arguments can be passed to a function
    1. Call by value (the default, as in earlier example)
    2. Call by reference

Function call by value

- The **call by value** method of passing arguments to a function copies the actual value of an argument into the formal parameter of the function
- In this case, changes made to the parameter inside the function have no effect on the argument

```
Before swap, value of a : 100
Before swap, value of b : 200
After swap, value of a : 100
After swap, value of b : 200
```

```c
void swap(int x, int y) {
   int temp;
   temp = x; /* save the value of x */
   x = y;    /* put y into x */
   y = temp; /* put temp into y */
   return;
}

int main () {
   /* local variable definition */
   int a = 100;
   int b = 200;
   printf("Before swap, value of a : %d\n", a );
   printf("Before swap, value of b : %d\n", b );
   /* calling a function to swap the values */
   swap(a, b);
   printf("After swap, value of a : %d\n", a );
   printf("After swap, value of b : %d\n", b );
   return 0;
}
```

Function call by reference

- The **call by reference** method of passing arguments to a function copies the **address of an argument** into the formal parameter
- Inside the function, the address is used to access the actual argument used in the call
- It means the changes made to the parameter affect the passed argument

```
Before swap, value of a : 100
Before swap, value of b : 200
After swap, value of a : 200
After swap, value of b : 100
```

```c
void swap(int *x, int *y) {
   int temp;
   temp = *x;     /* save the value at address x */
   *x = *y;       /* put y into x */
   *y = temp;     /* put temp into y */
   return;
}

int main () {
   /* local variable definition */
   int a = 100;
   int b = 200;
   printf("Before swap, value of a : %d\n", a );
   printf("Before swap, value of b : %d\n", b );
   swap(&a, &b);
   printf("After swap, value of a : %d\n", a );
   printf("After swap, value of b : %d\n", b );
   return 0;
}
```