C Programming

Class- BCA IInd Semester

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Outline

unit 5：Preprocessor

- Bitwise Operators
- Bitwise Shift Operators
- Masking
- XOR masking
- Bit Fields

Bitwise Operators

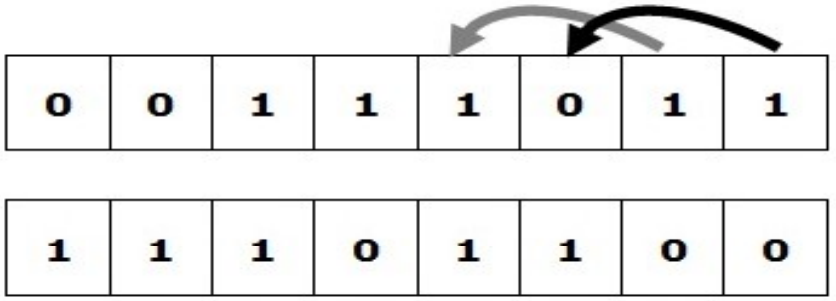
Bitwise operator works on bits and performs bit-by-bit operation.

Operator	Meaning	Remark
&	Bitwise AND	101 & 010 = 000
|	Bitwise OR	101 | 010 = 111
^	Bitwise EX-OR	111 ^ 010 = 101
<<	Shift left	<<100 = 001
>>	Shift right	>>100 = 010
~	Ones complement	~101 = 010

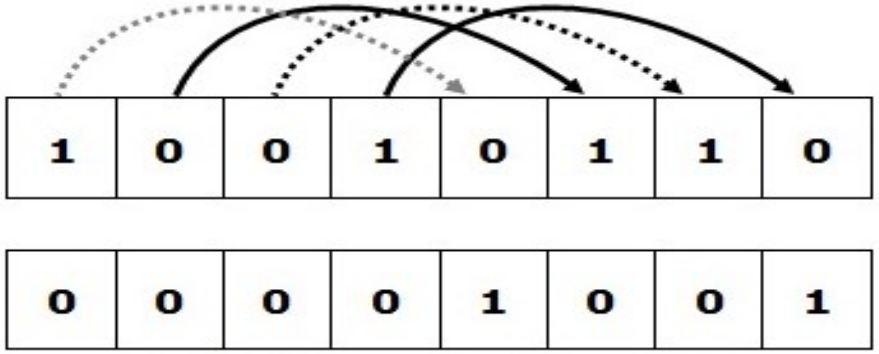
Bitwise Shift Operators (<<, >>)

- There are two shift operators – **Left shift** and **Right shift**. These operators shift the bits by the corresponding value, in other word's move the bits. The sign **<<** for left shift and **>>** for right shift.

For example C = A << 2; // left shift A by 2



For example D = B >> 4; // right shift B by 4



```
#include <stdio.h>   /*BITWISE*/
#include<conio.h>
void main()
{
  unsigned int a = 60;                    /* 60 = 0011 1100 */
  unsigned int b = 13;                    /* 13 = 0000 1101 */
  int c = 0;
  c = a & b;                             /* 12 = 0000 1100 */
  printf("Line 1 - Value of c is %d\n", c );
  c = a | b;                              /* 61 = 0011 1101 */
  printf("Line 2 - Value of c is %d\n", c );
  c = a ^ b;                              /* 49 = 0011 0001 */
  printf("Line 3 - Value of c is %d\n", c );
  c = ~a;                                 /*-61 = 1100 0011 */
  printf("Line 4 - Value of c is %d\n", c );
  c = a << 2;                            /* 240 = 1111 0000 */
  printf("Line 5 - Value of c is %d\n", c );
  c = a >> 2;                             /* 15 = 0000 1111 */
  printf("Line 6 - Value of c is %d\n", c );
  getch();
}
```

Masking

Masking is an operation in which we can selectively mask or filter the bits of a variable, such that some bits are to keep/change/remove a desired part of information.

Masking using Bitwise AND: More often in practice bits are "masked off" (or masked to 0) than "masked on" (or masked to 1). When a bit is ANDed with a 0, the result is always 0, i.e. Y AND 0 = 0. To leave the other bits as they were originally, they can be ANDed with 1, since Y AND 1 = Y.

```
  10100101 10100101
  00001111 00001111 (AND mask bits)
= 00000101 00000101
```

ch	b_7	b_6	b_5	b_4	b_3	b_2	b_1	b_0
mask	0	0	0	0	1	0	0	0
result = ch & mask	0	0	0	0	b_3	0	0	0

Masking using Bitwise OR: the principle of OR masking is that Y OR 1 = 1 and Y OR 0 = Y. Therefore, to make sure a bit is on, OR can be used with a 1. To leave a bit unchanged, OR is used with a 0.

```
  10010101 10100101
  11110000 11110000  (OR masking bits)
= 11110101 11110101
```

	b_7	b_6	b_5	b_4	b_3	b_2	b_1	b_0
ch	1	0	0	0	0	0	1	1
mask	0	0	0	0	1	0	0	0
ch | mask	1	0	0	0	1	0	1	1

XOR masking

- This can be achieved using the XOR (exclusive or) operation. XOR returns 1 if and only if an odd number of bits are 1. Therefore, if two corresponding bits are 1, the result will be a 0, but if only one of them is 1, the result will be 1. Therefore inversion of the values of bits is done by XORing them with a 1. If the original bit was 1, it returns 1 XOR 1 = 0. If the original bit was 0 it returns 0 XOR 1 = 1. Also note that XOR masking is bit-safe, meaning that it will not affect unmasked bits because Y XOR 0 = Y.

```
  10011101 10010101
  00001111  11111111  (XOR masking bits)
= 10010010 01101010
```

Bit Fields

- In C, we can specify size (in bits) of structure and union members. The idea is to use memory efficiently when we know that the value of a field or group of fields will never exceed a limit or is withing a small range.
- For example, consider the following declaration of date without the use of bit fields.

```
struct date {
   unsigned int d;
   unsigned int m;
   unsigned int y;
};

int main()
{
   printf("Size of date is %u bytes\n",  sizeof(struct date));
   struct date dt = { 31, 12, 2014 };
   printf("Date is %d/%d/%d", dt.d, dt.m, dt.y);
}
```

Output: Size of date is 12 bytes
Date is 31/12/2014

➢The above representation of ‘date’ takes 12 bytes on a compiler where an unsigned int takes 4 bytes. Since we know that the value of d is always from 1 to 31, the value of m is from 1 to 12, we can optimize the space using bit fields.

```
struct date
 {
    unsigned int d : 5;      // d has value between 1 and 31, so 5 bits  are
sufficient
    unsigned int m : 4;      // m has value between 1 and 12, so 4 bits are
sufficient
    unsigned int y;
};
 int main()
{
   printf("Size of date is %u bytes\n", sizeof(struct date));
   struct date dt = { 31, 12, 2014 };
   printf("Date is %d/%d/%d", dt.d, dt.m, dt.y);
   return 0;
}
```

Output: Size of date is 8 bytes
Date is 31/12/2014

```c
#include <stdio.h>

main()
{
        int x = 50, k=10;
        clrscr();
        printf("\n Value of x is %d ", x);
        printf("\n\n Value of k is %d ", k);

        printf("\n\n k = %d is Masking the value of x = %d \n", k, x);
        x = x ^ k;
        printf("\n After XOR Masking the Value of x is %d \n" , x);

        printf("\n k = %d is Masking the Changed Value of x = %d again", k,
        x = x ^ k;
        printf("\n\n Now the Value of x is changed again to %d " , x);
}
```

```
Output
Value of x is 50                //      Bit-Pattern : 00110010
Value of k is 10                //      Bit-Pattern : 00001010
k = 10 is Masking the value of x = 50
After XOR Masking the Value of x is 56          // Resultant    : 00111000
k = 10 is Masking the Changed Value of x = 56 again
Now the Value of x is changed again to 50       // Resultant    : 00110010
```

Exercise

1. Write a program to show right and left shifting using bitwise operators.
2. Write a program to illustrate the bitwise operator.
3. The information about colors is to be stored in bits of a **char** variable called **color. The bit number 0 to 6, each represent 7** colors of a rainbow, i.e. bit 0 represents violet, 1 represents indigo, and so on. Write a program that asks the user to enter a number and based on this number it reports which colors in the rainbow does the number represents.
4. In an inter-college competition, various sports and games are played between different colleges like cricket, basketball, football, hockey, lawn tennis, table tennis, carom and chess. The information regarding the games won by a particular college is stored in bit numbers 0, 1, 2, 3, 4, 5, 6, 7 and 8 respectively of an integer variable called **game. The college** that wins in 5 or more than 5 games is awarded the Champion of Champions trophy. If a number is entered through the keyboard, then write a program to find out whether the college won the Champion of the Champions trophy or not, along with the names of the games won by the college.

References

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Thanks