



**School of Computer Science
Faculty of Science**

**COMP-2650: Computer Architecture I: Digital Design
Fall 2020**

Lab#	Date	Title	Due Date	Grade Release Date
Lab 02	Sept 28-30, 2020	L02: Number Systems	Oct. 07, 2020 Wednesday Midnight AoE	Oct. 14, 2020

The objectives of the second lab will be for you to master the topics in number systems by implementing the algorithms with a programming language, herein, C/C++.

Step 1. Environment Setup

Our programming environment is the same as the previous lab (Lab 01). In this lab, we want to extend our program to support larger binary numbers and more operations. For instance, we want to support binary numbers of n digits. Also, we want to calculate its 1's or 2's complement.

Step2. Writing Modular Programs

Now, let's open our previous program that accepts two Boolean values and returns the AND of them. We used the standard type `int` for our program and use 0 for `false` and 1 for `true` values.

```
01 #include <stdio.h>
02 int main(void) {
03
04     int x;
05     int y;
06     scanf("%d", &x);
07     scanf("%d", &y);
08     printf("%d AND %d is %d", x, y, x & y);
09     return 0;
10 }
```

As seen, this program can accept one binary digit, (bit). We want to extend the program to accept binary numbers with more than a single digit. We know that C/C++ has arrays to store multiple items with the same data type. In C++, we can have arrays of `bool` like any other data types to store a binary number with more than one bit. In the following program, we create an array of 8 bits, also called Byte, as follows:

```
01 #include <stdio.h>
02 int main(void) {
03     setbuf(stdout, NULL);
04     bool x[8]; //Byte = 8 bits
05     printf("Enter a binary number:\n");
06     for(int i=0; i < MAX; i = i + 1){
07         scanf("%d", &x[i]);
08     }
09     printf("The binary number is:\n");
10     for(int i=0; i < MAX; i = i + 1){
11         printf("%d", x[i]);
12     }
13     return 0;
14 }
```

However, there is no Boolean data type in C. We can use an array of integer for our purpose, but we have to check the integer digits are only 0 and 1. In the following program, we simulate a Byte by an array of integers. We accept 8 digits (assuming all digits are in {0,1}) and apply AND digitwise:

```

01 #include <stdio.h>
02 #define MAX 8 //Byte = 8 bits
03 int main(void) {
04     setbuf(stdout, NULL);
05
06     int x[MAX];
07     int y[MAX];
08
09     printf("Enter the first binary number:\n");
10     for(int i=0; i < MAX; i = i + 1){
11         scanf("%d", &x[i]);
12     }
13     printf("Enter the second binary number:\n");
14     for(int i=0; i < MAX; i = i + 1){
15         scanf("%d", &y[i]);
16     }
17     int z[MAX];
18     for(int i=0; i < MAX; i = i + 1){
19         z[i] = x[i] & y[i];
20     }
21     printf("The first number AND second binary yield:\n");
22     for(int i=0; i < MAX; i = i + 1){
23         printf("%d", z[i]);
24     }
25
26     return 0;
27 }

```

Best practice in C is to write modular programs, that is, to implement any individual task in a function. For instance, for applying AND, we can write a function that accepts two arrays of binary digits in its argument. Unfortunately, in C, it is impossible to return an array (there is a workaround for this though. We'll explain it in future assignments). So, we can put the result in another array in the third argument as follows:

```

01 #include <stdio.h>
02 #define MAX 8 //Byte = 8 bits
03
04 void func_and(int a[], int b[], int result[]){
05     for(int i=0; i < MAX; i = i + 1){
06         result[i] = a[i] & b[i];
07     }
08 }
09 int main(void) {
10     setbuf(stdout, NULL);
11
12     int x[MAX];
13     int y[MAX];
14
15     printf("Enter the first binary number:\n");
16     for(int i=0; i < MAX; i = i + 1){
17         scanf("%d", &x[i]);
18     }
19     printf("Enter the second binary number:\n");
20     for(int i=0; i < MAX; i = i + 1){

```



```
21     scanf("%d", &y[i]);
22 }
23
24 int z[MAX];
25 func_and(x, y, z);
26 printf("The first number AND second binary yield:\n");
27 for(int i=0; i < MAX; i = i + 1){
28     printf("%d", z[i]);
29 }
30
31 return 0;
32}
```

Lab Assignment

You should complete the above program under the name of a project COMP2650_Lab02_{UWinID} that firstly outputs a menu of 7 commands as follows:

```
Enter the command number:
0) Exit
1) AND
2) OR
3) NOT
4) 1's complement
5) 2's complement
6) 2's complement*
```

Based on the chosen number of commands by the user, the program should then ask for the input(s). For instance, if a user selects (1), the program should accept two inputs as follows:

```
Enter the first binary number:
x0 =
x1 =
...
x7 =

Enter the second binary number:
y0 =
y1 =
...
y7 =
```

When the user enters the two binary numbers, the program should apply the AND command on the input x and y and print the result and comes back to the main menu.

However, if the user selects (4), the program should ask for one input only:

```
Enter the binary number:
x0 =
x1 =
...
x7 =
```

When the user enters the binary number, the program then applies the 1's complement operation on the input and prints out the result and comes back to the main menu. If the user selects (0), the program ends. Please allow the user to enter inputs within the range {0,1} only. For instance, if the user enters 2, -1, ..., print out an error message and come back to ask for correct inputs.



It is required to write a *modular* program according to the following instructions:

1. For each command in the menu, write a function and call the function to do the command:

```
void func_and(int a[], int b[], int result[]){}
void func_or(int a[], int b[], int result[]){}
void func_not(int a[], int result[]){}
void func_1s_comp(int a[], int result[]){}
void func_2s_comp(int a[], int result[]){}
void func_2s_comp_star(int a[], int result[]){}
```

2. To apply 1's complement, use the function for NOT (func_not).
3. To apply 2's complement, use the function for 1's complement (func_1s_comp).
4. There is another algorithm to compute the 2's complement of a binary number as follows:
 - Start from the right to left until you see digit 1, then pass it and NOT the digits after that. For instance, 2's complement of **110100** is **001100**.
For the 2's complement* (func_2s_comp_star), use this algorithm.

Deliverables

You will prepare and submit the program in one single zip file `COMP2650_Lab02_{UWinID}.zip` containing the following two items:

1. The entire project folder `COMP2650_Lab02_{UWinID}`
2. The result of the four commands in the file `COMP2650_Lab02_Results_{UWinID}.jpg`. Simply make a screenshot of the results and save it.
3. A lab report document in the PDF file `COMP2650_Lab02_Report_{UWinID}.pdf`. It should include:
 - a. Your name, UWinID, and student number
 - b. The description of the program that you attached, along with any prerequisites that are needed to build and run the program. *Please note that if your program cannot be built and run on our computer systems, you will lose marks.*

In sum, your final zip file for the submission includes 1 folder (entire project folder), 1 image (results snapshot) and 1 pdf (report). *Please follow the naming convention as you lose marks otherwise.* Instead of {UWinID}, use your own UWindsor account name, e.g., mine is hfani@uwindsor.ca, so,

```
COMP2650_Lab02_hfani.zip
- COMP2650_Lab02_hfani
- COMP2650_Lab02_Report_hfani.pdf
- COMP2650_Lab02_Results_hfani.jpg
```