CS200 - Computer Organization

Bits and Bytes

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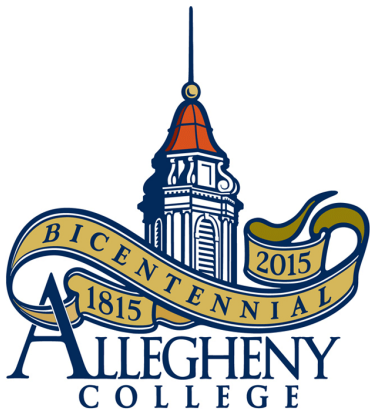
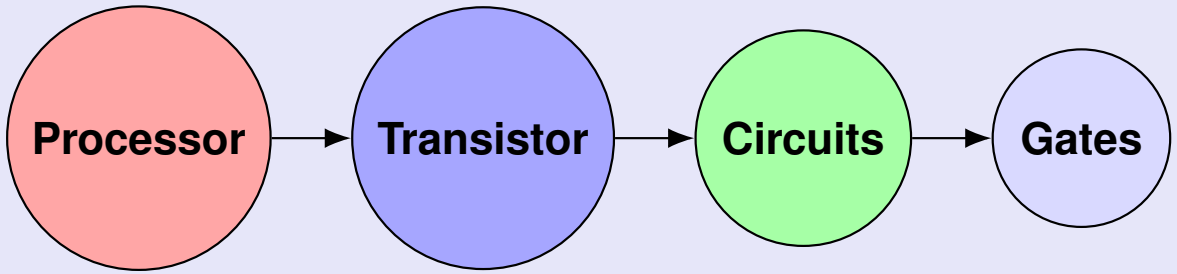


Computer Internals

- **Processor:** In computing, a processor is an electronic circuit which performs operations on some external data source, usually memory or some other data stream. (wiki)
- The goal of a processor, is to take in a binary input and produce a binary output.



Binary Match Table (1)

2 bit

b_1	b_0	d
0	0	0
0	1	1
1	0	2
1	1	3

3 bit

b_2	b_1	b_0	d
0	0	0	0
0	0	1	1
0	1	0	2
0	1	1	3
1	0	0	4
1	0	1	5
1	1	0	6
1	1	1	7

Binary Match Table (2)

4 bit

b_3	b_2	b_1	b_0	d
0	0	0	0	0
0	0	0	1	1
0	0	1	0	2
0	0	1	1	3
0	1	0	0	4
0	1	0	1	5
0	1	1	0	6
0	1	1	1	7
1	0	0	0	8

b_3	b_2	b_1	b_0	d
1	0	0	1	9
1	0	1	0	10
1	0	1	1	11
1	1	0	0	12
1	1	0	1	13
1	1	1	0	14
1	1	1	1	15

Observation from binary-match table (1)

- Bits are arranged from high to low. That is, $\{ b_x, b_{x-1}, b_{x-2}, b_{x-3}, ... \}$.
- The bit(s) in b_x flips after every 2^x number of rows.
- For example: b_3 flips after every 2^3 that is after every 8 rows.
- Binary representation of a decimal (2^x) is 1 followed by x number of 0's.
- For example, $2^3 = 8$ in decimal = 1000 in binary. $2^4 = 16$ in decimal = 10000.
  1. What is decimal (1024) in binary?
  2. What is decimal (4095) in binary?

Observation from binary-match table (2)

1. What is the maximum unsigned number that can be represented using 1 byte?
2. What is the maximum unsigned number that can be represented using 4 bytes?

We will discuss signed numbers (inclusion of negative numbers) at a later point.

Background on C

- C evolved from two previous languages, BCPL and B.
- Ken Thompson and Dennis M. Ritchie were the most prestigious 1983 **Turing Award** winners. Ken and Dennis modeled of C at Bell Labs.
- C initially became widely known as the development language of the UNIX operating system.

What is so special about C?

Built for Performance

- C is widely used to develop systems that demand performance, such as operating systems, embedded systems, real-time systems and communications systems.

Applications written in C

- Operating systems [Windows kernel, Linux, Mac.]
- Embedded systems [Video games, Car auto lock mechanism.]
- Real-time systems [Air Traffic control system]
- Communication systems [Tele communication]

```
https://www.toptal.com/c/after-all-these-years-the-world-is-still-powered-by-c-programming
```

Getting started in C

```
#include <stdio.h>
#define PI 3.1415926535
main() {
    double height, base, area, volume, radius;
    height = 10; base = 7;
    radius = base/2.0;
    area = 0.5*base*height; // area of a triangle
    volume = PI*radius*radius*height/3.0; // volume of cone
    printf("Area: %10.5f\nVolume: %10.5f\n",area,volume);
}
```

Preprocessor commands

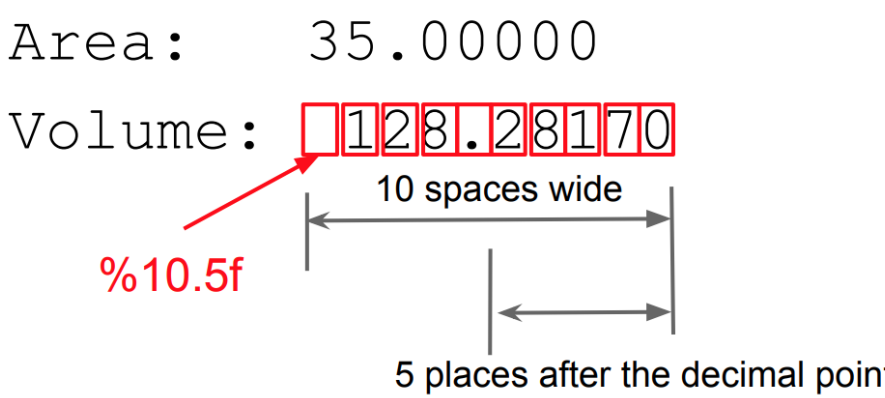
Same as "int main()" (int is the default return type)

Just like Java!

Format specifiers:

refer compute.c in coding folder

Getting started in C (contd)



(See K&R page 13 for more on formats)

Logical programming in C

```
#include <stdio.h>
main() {
    int n = 17;
    while (n > 1) {
        printf("%3d\n",n);
        if (n % 2 == 0){
            n = n/2;
        }
        else {
            n = 3*n+1;
        }
    }
}
```

Just like Java!

refer integers.c in coding folder

Output Displayed:

```
17
52
26
13
40
20
10
 5
16
 8
 4
 2
```

Loops in C

```
#include <stdio.h>
int main() {
    for (int i = 0; i < 10; i++) {
        printf("i is %d\n",i);
    }
}
```

```
notjava.c: In function 'main':
notjava.c:3:5: error: 'for' loop initial declarations are only allowed in C99 mode
     for (int i = 0; i < 10; i++) {
```

refer printloop.c in coding folder

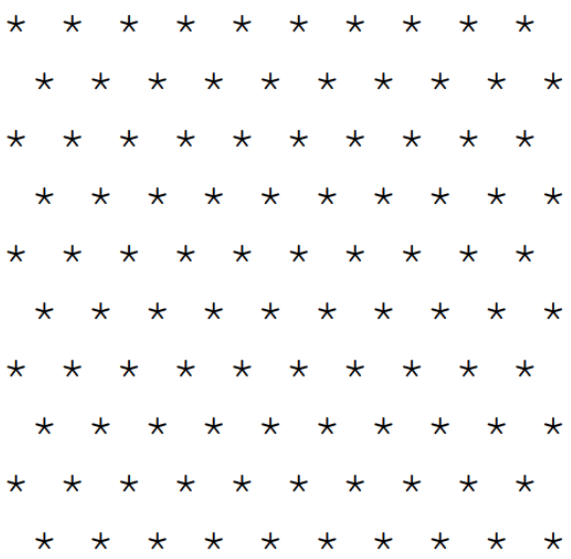
Nested for loop in C

```
// Draws a pretty picture
#include <stdio.h>
int main() {
    char star = '*', space = ' ';
    int row, col;
    for (row = 0; row < 10; row++) {
        for (col = 0; col < 10; col++) {
            if (row%2 == 0) {
                printf("%c%c",star,space);
            }
            else {
                printf("%c%c",space,star);
            }
        }
        printf("\n");
    }
}
```

refer pretty.c in coding folder

Nested for loop in C(contd)

Output Displayed:



ASCII Representation

- How do computers do things at the machine level?
- Primitive ”character-at-a-time” processing.
- What happens when your code does ”i = 3821;” ?

ASCII Vs Integers

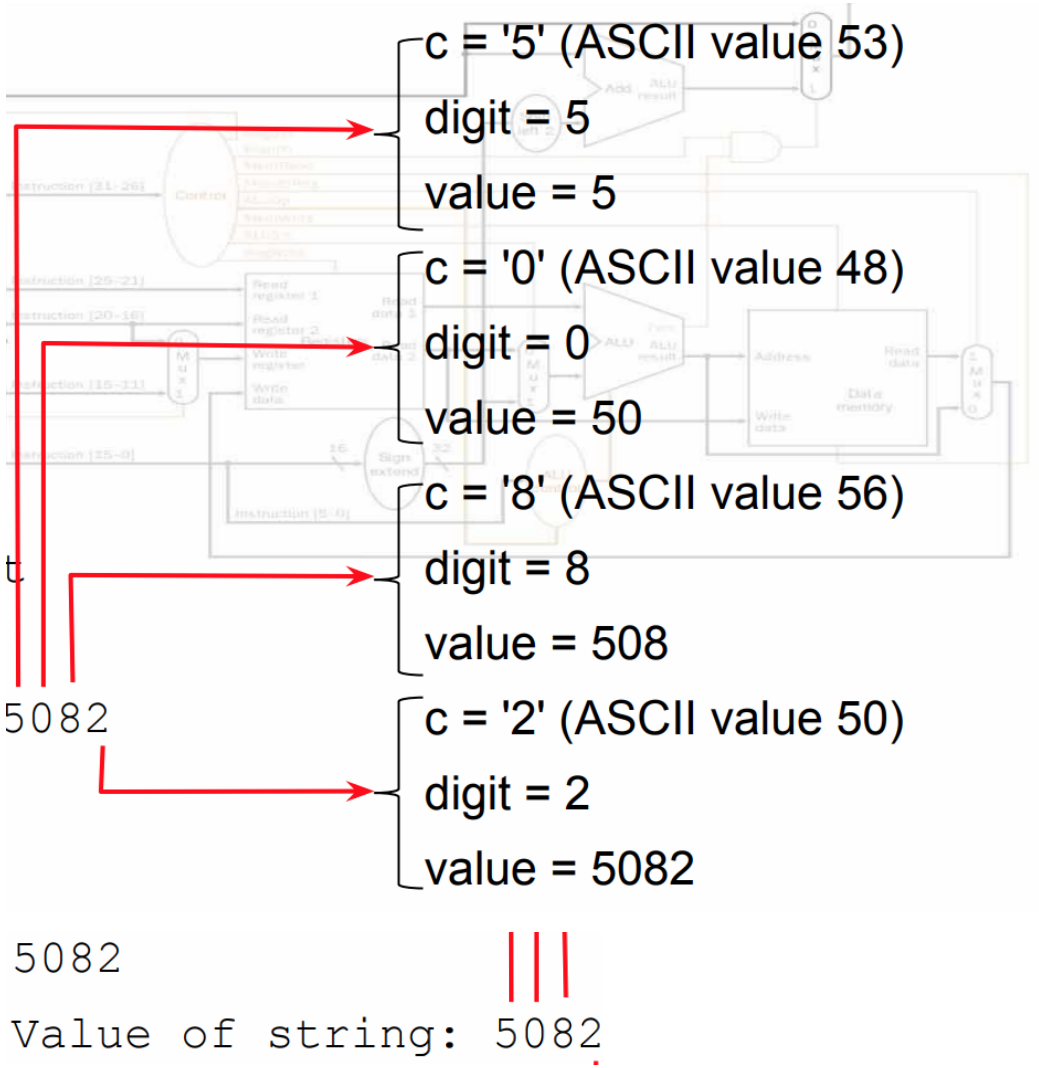
ASCII value	Character	ASCII value	Character
48	'0'	67	'C'
49	'1'	...	...
50	'2'	90	'Z'
...	...	...	...
57	'9'	97	'a'
...	...	98	'b'
65	'A'	...	...
66	'B'	122	'z'

Convert ASCII To Integers

```
#include <stdio.h>
main() {
    int c;          /* input character--assumed to be a digit */
    int digit;      /* the decimal digit corresponding to c */
    int value = 0; /* value of the input string as an int */
    while ((c = getchar()) != '\n') {
        if (c < '0' || c > '9') {     /* Check for error in input */
            printf("Error--non-digit in input\n");
            break;
        }
        digit = c - '0'; /* Convert ASCII to digit */
        value = 10 * value + digit; /* Combine with previous digits
    }
    printf("Value of string: %d\n",value);
}
```

refer ascii.c in coding folder

Convert ASCII To Integers(contd)



Convert ASCII To Integers(contd)

- In C, characters are treating like integers. All of the following are perfectly legal (and even make sense):

```
int c, position;
c = getchar(); /* read in a character, e.g, 'A' */
printf("char = '%c', ASCII value = %d\n",c,c);
position = c - 'A';
printf("position in alphabet: %d\n",position);
```

Output Displayed:

```
char = 'A', ASCII value = 65
position in alphabet: 0
```

refer position.c in coding folder

A simple IO program in C

```
#include <stdio.h>
int main()
{
    int a, b, c;
    printf("Enter the first number:");
    scanf("%d", &a);
    printf("Enter the second number:");
    scanf("%d", &b);
    c = a + b;
    printf("%d + %d = %d\n", a, b, c);
    return 0;
}
```

refer simpleio.c in coding folder

Reading Assignment

1. PH chapter 01 - section 1.3
2. KR chapter 01 - section 1.1 - 1.5

Questions

Do you have any questions from this class discussion?