EEE101: C Programming & Software Engineering I

Lecture 3: Variables and their Types

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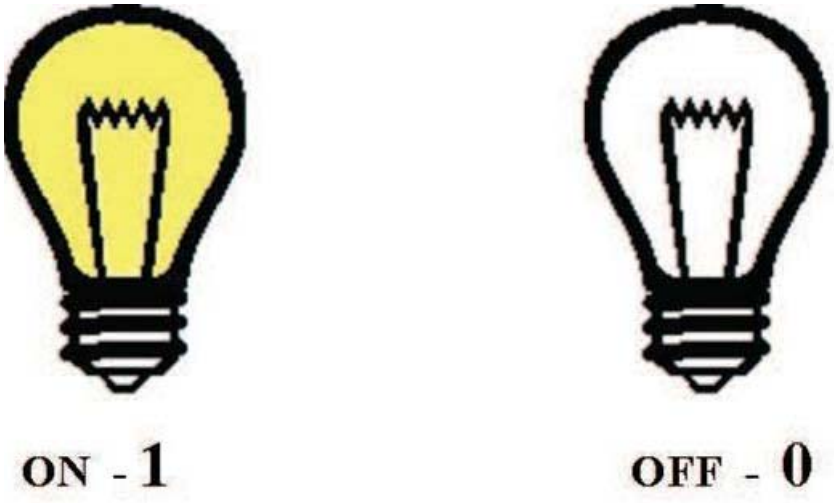
Outline of Today's Lecture (week 3)

- Numbers in the computer
- Variables and type conversions
- Characters, Arrays and Strings
- Basic Input and Output
- Operators (that's mathematical functions)
- But first……..

Lab Practice 1

- You should have learned how to write a program in C, how to compile it and then run it.
- Remember…as long as you use standard C code, you can use ANY C compiler, it will work!
- The C code (called Source Code) is written in a plain text file.
- The compiler produces an executable file (.exe) and an object file (.obj). The .exe is the runnable version of your source code. The .obj file was used by the compiler (you can ignore this file).

Numbers in the Computer



- Remember…in a computer all numbers are binary.
- Convenient for computer **because?**…
- not for us – we like decimal **because?**
- Hexadecimal (base 16) is a more convenient….

Numbers in the Computer

Dec	Binary	Hex	Dec	Binary	Hex
0	0000	0	8	1000	8
1	0001	1	9	1001	9
2	0010	2	10	1010	A
3	0011	3	11	1011	B
4	0100	4	12	1100	C
5	0101	5	13	1101	D
6	0110	6	14	1110	E
7	0111	7	15	1111	F

Easier to read than binary, one byte = 8 bits or 2 hex digits

Decimal 75 = 01001011 = 4B

You should be able to convert between the number bases.

Variables - Types and Conversions

Variables

- Remember – a variable is a *named memory location* that can hold a value (in binary)
- In C (and most languages) a variable must be declared before use.
- Declaration does 2 things:
  - Determines the type of variable
  - Reserves specific memory space for that variable
- Using the keyword **const** before the variable declaration prevents its value from being changed.

e.g. **const float** pi=3.141; or

const char msg[]="warning";

Enumeration Constant (enum)

- Another kind of constant used is used to assign a sequence of numbers to names
- Called an enumeration constant with the keyword **enum** e.g.

enum boolean {No, Yes}; assigns No=0 and Yes=1

enum month {Jan=1, Feb, Mar,…Nov, Dec};

assigns Jan=1, Feb=2… (Note you have to write all months)

- Advantage over **#define** – offers type check

Data Types and Ranges

Data Type	Description	Bytes	Range
short	short integer	2	-32,768 to 32,767
unsigned short	positive short integer	2	0 to 65,535
int	integer	2 or 4	see short or long
unsigned int	positive integer	2 or 4	see unsigned short or long
long	long integer	4	-2,147,483,648 to 2,147,483,647
unsigned long	positive long integer	4	0 to 4,294,967,295
float	single precision real number	4	3.4×10^{-38} to 3.4×10^{38} (6 digits of precision)
double	double precision real number	8	1.7×10^{-308} to 1.7×10^{308} (10 digits of precision)
long double	double precision real number	12	3.4×10^{-4931} to 3.4×10^{4931} (10 digits of precision)
char	character	1	-128 to 127
unsigned char	positive character	1	0 to 255

Computational Problems

- Real and integers are stored differently
- How does the computer deal with this e.g.

```
float answer;
int x=24, y=10;
answer=x/y;
```

What value is stored in answer?

Computational Problems

- Real and integers are stored differently
- How does the computer deal with this e.g.

```
float number;
int x=24, y=10;
answer=x/y;
```

What value is stored in answer? 2.0

How can the correct value be obtained?

Type Conversions

- This refers to the changing of one data type to another
- Two type conversions *implicit* and *explicit*
- **Why not just store everything in the same format?**

Type Conversions

- This refers to the changing of one data type to another
- Two type conversions *implicit* and *explicit*
- **Why not just store everything in the same format?**

  Data can be stored in most compact form and converted when needed
- Disadvantage

  Type mismatches can be missed by the compiler

Implicit Conversions

- When types are mixed then type conversions that can be are performed automatically
- Remember that a char is just a small integer value and can be used in mathematical operations
- There are some rules for these conversions:

Implicit Conversions

- **int** k=5, m=4, n; **float** x=1.5, y=2.1, z;

Context	Example	Explanation
Expression with binary operator and operands of different numeric types	k+x; value 6.5	Value of int variable k is converted to type double before operation
Assignment statement with double target and int expression	z=k/m; expression value is 1 value of z is 1.0	Expression is evaluated first. Result is converted to double for assignment
Assignment statement with int target and double expression	n=x*y; expression value is 3.15 value of n is 3	Expression is evaluated first. Result is converted to int for assignment. Fraction is lost.

Explicit Conversions

- You can force the use of a particular type and the implicit conversion can be ignored
- Use a cast operator to convert the type
- Note the cast does not change a value stored in variable, it just changes the type for the calculation.

```
int age;
age=1.2+5.978; automatic result is 7
age=(int)1.2+(int)5.978; casts convert values first
age=?
```

Explicit Conversions

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```
int age;
age=1.2+5.978; automatic result is 7
age=(int)1.2+(int)5.978; casts convert values first
age=6
```

Characters, Arrays and Strings

Characters and Arrays

- Characters

  Consist of any printable or non-printable character in the computers character set include: lowercase/uppercase letters, decimal digits, special characters and escape sequences.

  Generally stored in a single byte (8-bits)

- Arrays

  Ordered sequences of same type data elements

  Simply put, several memory cells in a row given the same name.

Defining an Array

- How to declare an array:

```
char name[20];
```

- This declares an array called name with 20 elements (i.e. name can store 20 characters)
- Brackets [] indicate an array
- An array MUST have a dimension (number of elements)
- Examples:

```
int attendance[15];
float  daily_temperature[30];
```

What do these mean??

Accessing Array Elements

- How can I use each element of my array
- The first element is always **0**
- **DO NOT** exceed array bounds (no one will check!)
- Consider:

```
float price[20]; /*declare an array 20 elements*/
price[0]=12.12; /*assign value to first element*/
price[1]=13.13; /*assign value to second element*/
…
price[20]=12.34; /*assign value to element 20?*/
```

What will happen here?

String Fundamentals

- A string is an array of characters ending with the NULL character or '\0'
- Can be written with double quotes "I am a string"
- Can be assigned when array is declared:
  - **char** firstname[] = "Walter";
  - **char** lastname[] = "White";
  - **char** fullname[] = "Walter White";
- **#define** can be used to create a string
  - **#define** TV "Breaking Bad"

String Fundamentals

- A string can also be defined by specifying individual characters:
  - **char** colour[] = {‘g’,’r’,’e’,’e’,’e’,’n’,’\0’};
  - This shows that each character is stored in its own element.

what would this print?

printf(“the third character is %c”,colour[3]);

String Library

- There is a library of string functions *string.h*
- Some examples:
  - strlen() – finds the length of a string
  - strcmp() – compares two strings character by character
  - strcpy() – copies a string from one array to another

```
#include<string.h>
#include<stdio.h>
#define NAME “Mark Leach”

main(){
printf(“My name has %d characters”,strlen(NAME));
}
```

Basic I/O Functions And Operations

Basic Input and Output

- Standard input functions (in *stdio.h*)
  - getchar() reads a character
  - scanf() input type must be specified
  - gets() reads strings
- Standard output functions (in *stdio.h*)
  - putchar() outputs a character
  - printf() output type must be specified
  - puts() outputs a string

The scanf() function (1/2)

- reads data from the standard input device *stdin* (usually the keyboard) and stores it in a variable

- General syntax:

  scanf("format specifier", &variable);

- The ampersand (&)
  - Specifies the memory address of the variable
- example:

```
int age;
printf("enter your age:");
scanf("%d",&age);
```

The scanf() function (2/2)

- Common format specifiers used in printf() and scanf() functions

Type	Specifier
int	%d
float	%f
double	%lf
char	%c
string	%s

- Add more specifiers to enter more than one argument:

```
float height, weight;
scanf("%f%f",&height,&weight);
```

getchar() and putchar()

- Single character reading and writing, examples:

```
#include<stdio.h>
main(){
char my_char;
printf("please type a character: ");
my_char=getchar();
printf("\n you typed the character: ");
putchar(my_char);
}
```

gets() and puts()

- Multiple character reading and writing
- scanf() reads strings using the specifier %s , however it cannot accept the space
- If the string to be read contains a space, the gets() function MUST be used

Example (1/2)

```
#include<stdio.h>
main()
{
char string1[50], string2[50];
printf("Enter a string less than 50 characters with spaces: \n");
gets(string1);
printf("you entered:");
puts(string1);
printf("Enter the same string\n");
scanf("%s",string2);
printf("you entered:");
puts(string2);
}
```

Example (2/2)

Sample output:

Enter a string less than 50 characters with spaces:

hello class

You entered: hello class

Enter the same string:

hello class

You entered: hello

Operators in C (Unary)

- Unary operators (involve one variable)

C operation	Operator	Example
Positive	+	a=+3
Negation	-	b=-a
Increment	++	i++
Decrement	--	i--

- The first assigns positive 3 to a
- The second assigns the negative of a to b
- i++ is equivalent to i = i + 1
- i-- is equivalent to i = i - 1

Pre/Post Increment/Decrement

- ++i and i++ or --i and i—
- These are different, the location of the operation (++ or --) decides when the operation happens
- Operation before variable is a pre operation
- Operation after variable is a post operation

```
int a=9;
printf("%d\n",a++);
printf("%d",a);
```

What would the output would be?

Pre/Post Increment/Decrement

What about in this case?:

```
int a=9;
printf("%d\n",++a);
printf("%d",a);
```

Assignment Operator

- Assignments can be written in a more shorthand way:

  i = i+2 is the same as i += 2

- the shorthand is denoted var op= value

Question: x*= y+1

Is this equal to x=x*y+1 or x=x*(y+1)?

Relational Operations

- Used to Compare Expressions:

Operator	*Meaning*
<	is **less** than
<=	is **less** than **or equal** to
!=	is **not equal**
==	is **equal to**
>	is **greater** than
>=	is **greater** than **or equal** to

Logical Operations

Used to combine one or more relational expressions

```
if ( (number>6) && (number<12) )
   printf("You are close!");
else
   printf("You Loose!");
```

Complex test expression – tests whether number lies within a range

Operator	*Meaning*
&&	*Logical "**and**":* True if **both** arguments are true
||	*Logical "**or**":* True if **one or both** arguments are true
!	Logical "**not**": changes True in False and False in True

Logical Operations

Table 4.3 The && Operator (and)

operand 1	operand2	operand 1 && operand2
nonzero (true)	nonzero (true)	1 (true)
nonzero (true)	0 (false)	0 (false)
0 (false)	nonzero (true)	0 (false)
0 (false)	0 (false)	0 (false)

Table 4.4 The || Operator (or)

operand 1	operand2	operand 1 || operand2
non zero (true)	nonzero (true)	1 (true)
nonzero (true)	0 (false)	1 (true)
0 (false)	nonzero (true)	1 (true)
0 (false)	0 (false)	0 (false)

Table 4.5 The ! Operator (not)

operand 1	!operand 1
nonzero (true)	0 (false)
0 (false)	1 (true)

Precedence – Relational Operators

Assignment operators	Relational operators	Arithmetic Operators

`x>y+2` means the same as `x>(y+2)`

`x=y>2` means the same as `x=(y>2)`

Precedence – Logical Operators

Arithmetic operators	!	()

Lower — Precedence — Higher

Assignment operators	||	&&	Relational operators

```
x=3 > 5 && 10 > 23 || 4 > 2
```

means the same as

```
x=((3 > 5) &&(10 > 23)) || (4 > 2)
x=((False && False) || True)
```

Bitwise Operators

- The following are bitwise operators:

  &, |, ^, <<, >>, ~

- What do they mean? What is the difference between these operators and the relational operators?

- They are usually used for C programming for embedded systems.

Quiz

- Which of the following evaluates to **true**?
- Assume: P = true, Q = false, R = true

1) (!P || R) && Q
2) !(Q && R) && P
3) !(P && R) || Q
4) P && !Q && !R

Quiz

- Can you work out what the following logical expression is?

  i<lim-1 && (c=getchar()) != '\n' && c != EOF

  What will happen, if we remove the parentheses surrounding c=getchar()?

- The unary negation operator "!" converts a non-zero operand into 0 and a zero into 1.

  Can you tell, assuming valid is 0, what the following statement does?

  ```
  if (!valid)
      ……;
  ```

  Can you rewrite this statement using another relational operator?

I know that was long…but…
Thank you again for your attention

See you next after the holiday…
Happy mid Autumn Festival ☺