Computer Programming

Irwan Prasetya Gunawan, Ph.D

Sampoerna University
ipg@ieee.org

01: Basic: Elements of C Program, Identifiers, Data Types

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Contents

C Variables Names (1)

Variable Names

- Names may contain letters, digits and underscores
- The first character must be a letter or an underscore.
  - the underscore can be used but watch out!!
- Case matters!
- C keywords cannot be be used as variable names.

```
present, hello, y2x3, r2d3, ...     /* OK */
_1993_tar_return                    /* OK but don't */
Hello#there                         /* illegal */
double                              /* shouldn't work */
2fartogo                            /* illegal */
```

C Variables Names (2)

Suggestions regarding variable names

- DO: use variable names that are descriptive
- DO: adopt and stick to a standard naming convention
  - sometimes it is useful to do this consistently for the entire software development site

- AVOID: variable names starting with an underscore
  - often used by the operating system and easy to miss
- AVOID: using uppercase only variable names
  - generally these are pre-processor macros (later)

C Basic Types (1)

- There are only a few basic data types in C
  - char: a single byte, capable of holding one character
  - int: an integer of fixed length, typically reflecting the natural size of integers on the host machine (i.e., 32 or 64 bits)
  - float: single-precision floating point
  - double: double precision floating point

C Basic Types (2)

- There are a number of qualifiers which can be applied to the basic types
  - length of data
    - short int:
      - "shorter" int, <= number of bits in an int
      - can also just write "short"
    - long int:
      - a "longer int", >= number of bits in an int
      - often the same number of bits as an int
      - can also just write "long"
    - long double
      - generally extended precision floating point
  - signed and unsigned
    - unsigned int
      - an int type with no sign
      - if int has 32-bits, range from $0..2^{32}-1$
      - also works with long and short
    - unsigned char
      - a number from 0 to 255
    - signed char
      - a number from –128 to 127 (8-bit signed value)
      - very similar to byte in Java

C Basic Types (3)

- All types have a fixed size associated with them
  - this size can be determined at compile time
- Example storage requirements

DATA	Bytes Required
The letter *x* (char)	1
The number 100 (int)	4
The number 120.145 (double)	8

- These numbers are highly variable between C compilers and computer architectures.
- Programs that rely on these figures must be very careful to make their code portable (ie. Try not to avoid relying on the size of the predefined types)

C Basic Types (4)

Numeric Variable Types

- Integer Types:
  - Generally 32-bits or 64-bits in length
  - Suppose an int has b-bits
    - a signed int is in range $-2^{b-1}..2^{b-1}-1$
      - -32768 .. 32767 (32767+1=-32768)
    - an unsigned int is in range $0..2^{b}-1$
      - 0 .. 65535 (65535+1=0)
    - no error message is given on this "overflow"
- Floating-point Types:
  - Generally IEEE 754 floating point numbers
    - float (IEEE single): 8 bits exponent, 1-bit sign, 23 bits mantissa
    - double (IEEE double): 10 bits exponent, 1-bit sign, 53 bits mantissa
    - long double (IEEE extended)
  - Only use floating point types when really required
    - they do a lot of rounding which must be understood well
    - floating point operations tend to cost more than integer operations

C Basic Types (5)

A typical 32-bit machine

Type	Keyword	Bytes	Range
character	char	1	-128...127
integer	int	4	-2,147,483,648...2,147,438,647
short integer	short	2	-32768...32367
long integer	long	4	-2,147,483,648...2,147,438,647
long long integer	long long	8	-92233720368547758O8 … 92233720368547758O7
unsigned character	unsigned char	1	0...255
unsigned integer	unsigned int	2	0...4,294,967,295
unsigned short integer	unsigned short	2	0...65535
unsigned long integer	unsigned long	4	0...4,294,967,295
single-precision	float	4	1.2E-38...3.4E38
double-precision	double	8	2.2E-308...1.8E308

Formatted Printing with printf (1)

- The printf function is used to output information (both data from variables and text) to standard output.
  - A C library function in the <stdio.h> library.
  - Takes a format string and parameters for output.
- printf(format string, arg1, arg2, …);
  - e.g. printf("The result is %d and %d\n", a, b);
- The format string contains:
  - Literal text: is printed as is without variation
  - Escaped sequences: special characters preceeded by \
  - Conversion specifiers: % followed by a single character
    - Indicates (usually) that a variable is to be printed at this location in the output stream.
    - The variables to be printed must appear in the parameters to printf following the format string, in the order that they appear in the format string.

Formatted Printing with printf (2)

- Conversion Specifiers

Specifier	Meaning
%c	Single character
%d	Signed decimal integer
%x	Hexadecimal number
%f	Decimal floating point number
%e	Floating point in “scientific notation”
%s	Character string (more on this later)
%u	Unsigned decimal integer
%%	Just print a % sign
%ld, %lld	long, and long long

- There must be one conversion specifier for each argument being printed out.
- Ensure you use the correct specifier for the type of data you are printing.

Formatted Printing with printf (3)

- Escape Sequences:

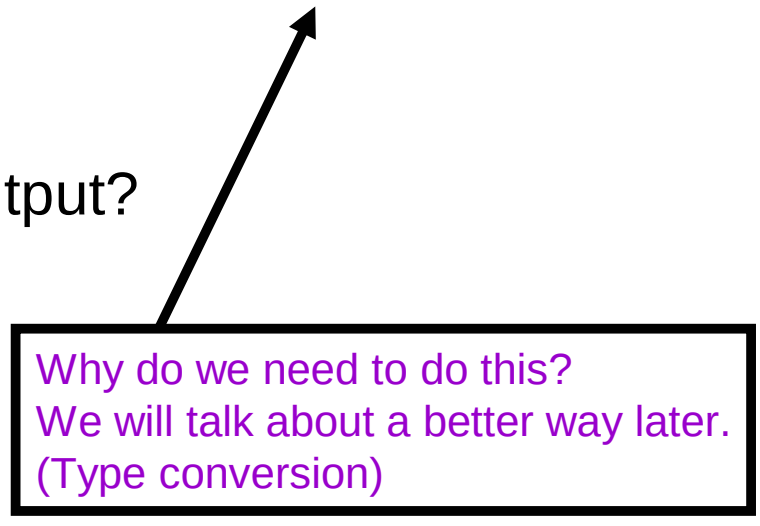
Sequence	Meaning
\a	Bell (alert)
\b	Backspace
\n	Newline
\t	Horizontal tab
\\	Backslash
\'	Single quote
\"	Double quotation
\x*hh*	ASCII char specified by hex digits *hh*
ooo	ASCII char specified by octal digits *ooo*

Formatted Printing with printf (4)

- An example use of printf

```
#include <stdio.h>
int main() {
   int ten=10,x=42;
   char ch1='o', ch2='f';
   printf("%d%% %c%c %d is %f\n",
          ten,ch1,ch2,x, 1.0*x / ten );
   return 0;
}
```

- What is the output?



Reading Numeric Data with scanf (1)

- The scanf function is the input equivalent of printf
  - A C library function in the <stdio.h> library
  - Takes a format string and parameters, much like printf
  - The format string specifiers are nearly the same as those used in printf
- Examples:

```
scanf ("%d", &x);       /* reads a decimal integer */
scanf ("%f", &rate);    /* reads a floating point value */
```

- The ampersand (&) is used to get the “address” of the variable
  - All the C function parameters are “passed by value”.
  - If we used scanf("%d",x) instead, the value of x is passed. As a result, scanf will not know where to put the number it reads.
  - More about this in Section 15 (“Functions”)

Reading Numeric Data with scanf (2)

- Reading more than one variable at a time:
  - For example:

    ```
    int n1, n2;  float f;
    scanf("%d%d%f",&n1,&n2,&f);
    ```

  - Use white spaces to separate numbers when input.

    ```
    5      10      20.3
    ```

- In the format string:
  - You can use other characters to separate the numbers

    ```
    scanf("value=%d,ratio=%f", &value,&ratio);
    ```

    - You must provide input like:

      ```
      value=27,ratio=0.8
      ```

  - scanf returns an int
    - If end-of-file was reached, it returns EOF, a constant defined in <stdio.h>
    - Otherwise, it returns the number of input values correctly read from standard input.

Reading Numeric Data with scanf (3)

- One tricky point:
  - If you are reading into a long or a double, you must precede the conversion specifier with an **l** (a lower case L)
  - Example:

```
int main() {
   int x;
   long y;
   float a;
   double b;
   scanf("%d %ld %f %lf", &x, &y, &a, &b);
   return 0;
}
```

Type Conversion

- C allows for conversions between the basic types, implicitly or explicitly.
- Explicit conversion uses the cast operator.
- Example 1:

```
int x=10;
float y,z=3.14;
y=(float) x;       /* y=10.0 */
x=(int) z;         /* x=3     */
x=(int) (-z);      /* x=-3   -- rounded approaching zero */
```

- Example 2:

```
int i;
short int j=1000;
i=j*j;                /* wrong!!! */
i=(int)j * (int)j;    /* correct */
```

Implicit Conversion

- If the compiler expects one type at a position, but another type is provided, then implicit conversion occurs.
- Conversion during assignments:

```
char c='a';
int i;
i=c;    /* i  is assigned the ASCII code of ‘a’ */
```

- Arithmetic conversion – if two operands of a binary operator are not the same type, implicit conversion occurs:

```
int i=5 , j=1;
float x=1.0 , y;
y = x / i;          /* y = 1.0 /  5.0  */
y = j / i;          /* y = 1 / 5  so  y = 0 */
y = (float) j / i;   /* y = 1.0 / 5  */
                    /* The cast operator has a higher precedence */
```

Example

The sizeof() function returns the number of bytes in a data type.

```
int main() {
  printf("Size of char ..... = %2d byte(s)\n", sizeof(char));
  printf("Size of short ..... = %2d byte(s)\n", sizeof(short));
  printf("Size of int ..... = %2d byte(s)\n", sizeof(int));
  printf("Size of long long …… = %2d byte(s)\n", sizeof(long long));
  printf("Size of long ..... = %2d byte(s)\n", sizeof(long));
  printf("Size of unsigned char. = %2d byte(s)\n", sizeof (unsigned char));
  printf("Size of unsigned int.. = %2d byte(s)\n", sizeof (unsigned int));
  printf("Size of unsigned short = %2d byte(s)\n", sizeof (unsigned short));
  printf("Size of unsigned long. = %2d byte(s)\n", sizeof (unsigned long));
  printf("Size of float ..... = %2d byte(s)\n", sizeof(float));
  printf("Size of double ..... = %2d byte(s)\n", sizeof(double));
  printf("Size of long double .. = %2d byte(s)\n", sizeof(long double));
  return 0;
}
```

Example

Results of a previous run of this code on obelix ...

Size of char	= 1 byte(s)
Size of short	= 2 byte(s)
Size of int	= 4 byte(s)
Size of long	= 4 byte(s)
Size of long long	= 8 byte(s)
Size of unsigned char	= 1 byte(s)
Size of unsigned int	= 4 byte(s)
Size of unsigned short	= 2 byte(s)
Size of unsigned long	= 4 byte(s)
Size of float	= 4 byte(s)
Size of double	= 8 byte(s)
Size of long double	=16 byte(s)

Creating Simple Types

- typedef creates a new name for an existing type
  - Allows you to create a new name for a complex old name
- Generic syntax

```
typedef  oldtype  newtype;
```

- Examples:

```
typedef  long  int32;    /* suppose we know an int has 32-bits */
typedef  unsigned char  byte;  /* create a byte type */
typedef  long double extended;
```

- These are often used with complex data types
  - Simplifies syntax!

Variable Declaration (1)

- Generic Form

```
typename    varname1, varname2, ...;
```

- Examples:

```
int  count;
float a;
double percent, total;
unsigned char x,y,z;
long int aLongInt;
long AnotherLongInt
unsigned long a_1, a_2, a_3;
unsigned long int b_1, b_2, b_3;
typedef long int32;
int32 n;
```

- Where declarations appear affects their scope and visibility
  - Rules are similar to those in Java
  - Declaration outside of any function are for global variables
    - e.g., just before the main routine

Variable Declaration (2)

Initialization

- ALWAYS initialize a variable before using it
  - Failure to do so in C is asking for trouble
  - The value of an uninitialized variables is undefined in the C standards
- Examples:

```
int count;          /* Set aside storage space for count */
count = 0;          /* Store 0 in count */
```

- This can be done at definition:

```
int count = 0;
double percent = 10.0,  rate = 0.56;
```

- Warning: be careful about “out of range errors”

```
unsigned int value = -2500;
```

  - The C compiler does not detect this as an error
    - What do you suspect it does?

Constants (1)

Constants

- You can also declare variables as being constants
  - Use the const qualifier:

```
const double pi=3.1415926;
const int maxlength=2356;
const int val=(3*7+6)*5;
```

Note: simple computed values are allowed
• must be able to evaluate at *compile time*

  - Constants are useful for a number of reasons
    - Tells the reader of the code that a value does not change
      - Makes reading large pieces of code easier
    - Tells the compiler that a value does not change
      - The compiler can potentially compile faster code
- Use constants whenever appropriate
- NOTE: You will get errors with the cc compiler --- use the gcc compiler (newer)

Constants (2)

Preprocessor Constants

- These are an older form of constant which you still see
  - There is a potential for problems, so be careful using them!
- Generic Form:

  #define CONSTNAME literal
  - Generally make pre-processor constants all upper case (convention).
- Example:

  #define PI 3.14159
- What really happens
  - The C preprocessor runs before the compiler.
  - Every time it sees the token PI, it substitutes the value 3.14159.
  - The compiler is then run with this “pre-processed” C code.
- Why this is dangerous?
  - Hard to determine the value of a multiply-defined constant (which you are allowed to create)

Constants (3)

- An example of constants in use:

```
#include <stdio.h>
#define GRAMS_PER_POUND 454
const int FARFARAWAY = 3000;
int main ()
{
   int weight_in_grams, weight_in_pounds;
   int year_of_birth, age_in_3000;
   printf ("Enter your weight in pounds: ");
   scanf  ("%d", &weight_in_pounds);
   printf ("Enter your year of birth: ");
   scanf  ("%d", &year_of_birth);
   weight_in_grams = weight_in_pounds * GRAMS_PER_POUND;
   age_in_3000 = FARFARAWAY - year_of_birth;
   printf ("Your weight in grams = %d\n", weight_in_grams);
   printf ("In 3000 you will be %d years old\n", age_in_3000);
   return 0;
}
```

Literals in C

- Literals are representations of values of some types
  - C allows literal values for integer, character, and floating point types
- Integer literals
  - Just write the integer in base 10

    ```
    int y=-46;
    ```
  - We will discuss base 8 and base 16 literals later
- Character literals
  - Character literals are specified with a single character in single quotes

    ```
    char ch='a';
    ```
  - Special characters are specified with escape characters
    - Recall the discussion of ‘escaped’ characters with the shell
    - We will discuss these later
- Floating point literals
  - Just write the floating point number

    ```
    float PI=3.14159;
    ```
  - Can also use mantissa/exponent (scientific) notation

    ```
    double minusPItimes100 = -3.14159e2
    ```

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