A Shotgun Introduction to C

Stephen A. Edwards

Columbia University

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C History

Developed between 1969 and 1973 along with Unix

Due mostly to Dennis Ritchie

Designed for systems programming

- Operating systems
- Utility programs
- Compilers
- Filters

Evolved from B, which evolved from BCPL
Original machine, a DEC PDP-11, was very small:

24K bytes of memory, 12K used for operating system

Written when computers were big, capital equipment

Group would get one, develop new language, OS
int add() /* Function that returns an integer */
{
    int x, y, z; /* Variables x, y, and z are integers */
    x = 38; /* Set x to 38 */
    y = 4; /* Set y to 4 */
    z = x + y; /* Set z to the sum of x and y */
    return z; /* Return z as the result of add() */
}

End statements with semicolons

Text between /* and */ is ignored (a comment)

Programs are mostly function definitions and global variables.
Variables

Names must start with a letter; may contain letters, numbers, and underscores.

```plaintext
a A a_variable aVariable a50 ex 12_  /* OK */
two-words 42_is_the_answer  /* BAD */
```

Must be declared before they’re used

```plaintext
int a, b, c;  /* 32-bit signed binary integers */
char c, d;    /* Single letter, digit, etc. */

a = 42;
b = 18;
f = 3;     /* BAD: f not declared */
c = 'o';
d = '#';
q = '4';  /* BAD: q not declared */
```
Constants

```
#define ROWS 10
#define COLUMNS 40

pos = y * COLUMNS + rows;
```

This turns into

```
pos = y * 40 + rows;
```

The “#” must be in the leftmost column.
Common Operators

```c
int a, b, c;

a = b + c;  /* Addition */

a = b - c;  /* Subtraction */

a = -(b + c); /* Negation */

a = b * c; /* Multiplication */

a = b / c; /* Division (integer result) */

a = b % c; /* Remainder (modulus) */

a = b < c; /* a is non-zero if b is less than c */

a = b > c; /* non-zero if b is greater than c */

a = b <= c; /* b less than or equal to c */

a = b >= c; /* b greater than or equal to c */

a = b == c; /* a is non-zero if b is equal to c */

a = b != c; /* a is non-zero if b different than c */
```
Assignment Operators

A convenient shorthand:

```c
a += 3;  // Increase a by 3
a = a + 3;  // Equivalent
b *= 2;  // Double b
b = b * 2;  // Equivalent
```

Most operators have assignment variants.
Bitwise Operators

Internally, numbers represented in binary.

\[
10100101_2 = 1 \times 2^7 + 0 \times 2^6 + 1 \times 2^5 + 0 \times 2^4 + \\
0 \times 2^3 + 1 \times 2^2 + 0 \times 2^1 + 1 \times 2^0 \\
= 128 + 32 + 4 + 1 \\
= 165_{10}
\]

Bitwise operators work directly on bits:

\[
\begin{array}{cccc}
& 10110 & & 10110 & & 10110 \\
\text{AND: } & \& 10011 & \text{OR: } & | 10011 & \text{XOR: } & ^1 10011 \\
& 10010 & & 10111 & & 00101
\end{array}
\]
Increment/Decrement Operators

\[ a = a + 1; /* Common operation */ \]
\[ a += 1; /* One shorthand */ \]
\[ a++; /* Even more succinct */ \]

\[ \textbf{for} (i = 0 ; i < 10 ; i++) \{ /* Very common idiom */} \]
\[ /* i = 0, 1, 2, \ldots, 9 */ \]
\[ \} \]

\[ a = 3; \]
\[ b = a++; /* Postincrement: means } b = 3; a = 4; */ \]
\[ b = ++a; /* Preincrement: means a = 5; b = 5; */ \]

\[ a = 3; \]
\[ b = a--; /* Postdecrement: means b = 3; a = 2; */ \]
\[ b = --a; /* Predecrement: means a = 1; b = 1; */ \]
The If-Else Statement

```java
if (a == 3)
    c = 2; /* Runs if a is 3. One statement: braces optional */

if (b == 4 && c == 2) {
    /* && is logical AND */
    c = 5; /* Runs if b is 4 and c is 2 */
    a = a + 3;
} /* Two statements: braces mandatory */

if (a > b) {
    c = 1; /* Runs if a is greater than b */
} else {
    c = 5; /* Runs if a is not greater than b */
}

if (a > b || c == 3) { /* || is logical OR */
    c = 5; /* Runs if a is greater than b or c is 3 */
} else {
    a = b + 2;
}
```
The Switch Statement: A Multiway Conditional

```c
switch (a + 1) {
    case 2:
        c = 8; /* Runs if a is 1 */
        b = 2;
        break;

    case 0:
    case 1: /* Multiple cases allowed */
        b = 3; /* Runs if a is -1 or 0 */
        break;

    case 42: /* Case labels need not be contiguous */
        c = 12;
        /* No break: falls through to next case! */

    case 4:
        c = 15; /* Runs if a is 3 or 41 */
        break;

    default: /* a default is optional */
        c = 0; /* Runs if no other case matches */
        break; /* Good style */
}
```
The While Statement

```c
int gcd(int a, int b)
{
    while (a != b) /* Repeat while a and b are different */
    {
        if (a > b)
            a -= b; /* a is larger; subtract b from it */
        else
            b -= a; /* b is larger; subtract a from it */
    }
    return a;
}
```
The For Statement

```c
/* Sum the numbers from 1 to n */
int sumup(int n)
{
    int i, s;
    i = 0;
    s = 0;
    while (i <= n) {
        s += i;
        i += 1;
    }
    return s;
}
```

```c
/* Sum the numbers from 1 to n */
int sumup(int n)
{
    int i, s;
    s = 0;
    for (i = 0 ; i <= n ; i += 1)
        s += i;
    return s;
}
```
```c
int i;
int a[10];         /* Array of 10 integers */
int b[] = { 2,3,7,6 }; /* Initial values */

a[0] = 3;
a[2] = 5;
a[9] = 18;
a[10] = 42;        /* BAD: only a[0] ... a[9] */
a[-1] = 2;          /* BAD: positive indexes only */

a[1] = b[0];        /* a[0] = 2 */
b[3] = 42;

i = 5;
a[i] = 42;          /* a[5] = 42; */
i = 4;
a[i] = 10;          /* a[4] = 10; */
```
Strings

/* Strings are null-terminated arrays of characters */

char name1[] = "Stephen";
/* is equivalent to */
char name2[] = { 'S', 't', 'e', 'p', 'h', 'e', 'n', 0};

name1[5] = 'a';

/* name1 now "Stephan" */
struct point { /* Define an aggregate type "struct point" */
    int x;
    int y;
};

struct point p; /* Declare a new point */
p.x = 10; /* Set its coordinates */
p.y = 15;

printf("(%d,%d)\n", p.x, p.y);

struct point q = { 320, 200 }; /* Initialize contents */
p = q; /* Copy one point to another */

struct rect {
    struct point southwest;
    struct point northeast;
};

struct rect r;
r.southwest.x = 10;
r.southwest.y = 5;
r.northeast.x = 125;
r.northeast.y = 200;
Functions

```c
int num_calls = 0; /* global variable */

int power(int base, int n)
{
    int p; /* Different than main’s p */

    for ( p = 1 ; n > 0 ; --n )
        p *= base;

    num_calls++;

    return p;
}

int main() /* main function always runs first */
{
    int n, p;

    n = power(2, 5); /* n = 32 */
    p = power(3, 3); /* p = 27 */
    p = num_calls; /* p = 2 */
}
```
## Pointers

```c
int x = 1, y = 2;
int *ip;
```
Pointers

```c
int x = 1, y = 2;
int *ip;

ip = &x;
```
Pointers

```
int x = 1, y = 2;
int *ip;

ip = &x;
y = *ip;
```
Pointers

```c
int x = 1, y = 2;
int *ip;

ip = &x;
y = *ip;
*ip = 0;
```
void swap(int x, int y)
{
    int temp;
    temp = x;
    x = y;
    y = temp;
}

Does this work?
Pointers

```c
void swap(int x, int y)
{
    int temp;
    temp = x;
    x = y;
    y = temp;
}

void swap(int *px, int *py)
{
    int temp;

    temp = *px; /* get data at px */
    *px = *py; /* get data at py */
    *py = temp; /* write data at py */
}

void main()
{
    int a = 1, b = 2;

    /* Pass addresses of a and b */
    swap(&a, &b);

    /* a = 2 and b = 1 */
}
```

Does this work? Nope.
Arrays and Pointers

int a[10];
Arrays and Pointers

int a[10];
int *pa = &a[0];
Arrays and Pointers

```c
int a[10];
int *pa = &a[0];
pa = pa + 1;
```
Arrays and Pointers

```c
int a[10];
int *pa = &a[0];
pa = pa + 1;
pa = &a[1];
```
**Pointers and Structs**

```c
struct point {
    int x;
    int y;
};

struct point p, *pp;

p.x = 100;
p.y = 200;

pp = &p;  /* pp now points to p */

(*pp).x = 50;  /* Assign to x field of p */
pp->x = 50;  /* Equivalent */
pp->y = 42;
```
strlen: An Example

int strlen(const char *s)
{
    int n;

    for (n = 0 ; *s != '\0' ; s++)
        n++;

    return n;
}

void main()
{
    char ste[] = "Stephen";
    int l = strlen(ste);
}
Separate Compilation

file1.c

```c
extern void bar();
char a[] = "Hello";

int main() {  
    bar();
}

void baz(char *s) {  
    printf("%%\%%s", s);
}
```

file2.c

```c
extern char a[];
extern void baz(char *);

static char b[6];

void bar() {  
    strcpy(b, a);
    baz(b);
}
```
Better Style: Header Files

**myfiles.h**

```c
#ifndef _MYFILES_H
#define _MYFILES_H

/* in file1.c */
extern void bar();
extern char a[];

/* in file2.c */
extern void baz(char *);

#endif
```

**file1.c**

```c
#include "myfiles.h"

char a[] = "Hello";
int main() {
  bar();
}

void baz(char *s) {
  printf("%\%%s", s);
}
```

**file2.c**

```c
#include "myfiles.h"

static char b[6];

void bar() {
  strcpy(b, a);
  baz(b);
}
```