A Shotgun Introduction to C

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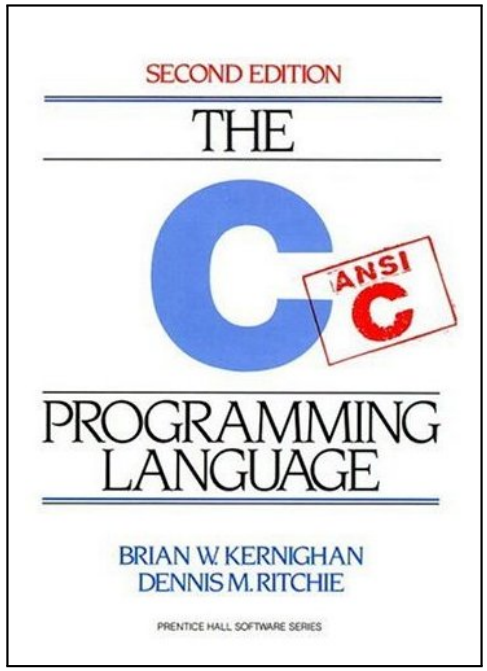


C History

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

C History

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

Adding Two Numbers

```
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.

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

Must be declared before they're used

```
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 */
```

Types of Integers

```
int a;              /* 32 bits: -2147483648 to 2147483647 */

unsigned b;         /* 32 bits: 0 to 4294967295 */

short c;            /* 16 bits: -32768 to 32767 */

unsigned short d;   /* 16 bits: 0 to 65535 */

signed char e;      /*  8 bits: -128 to 127 */

unsigned char f;    /*  8 bits: 0 to 255 */
```

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

```
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:

```
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.

$$
\begin{aligned}
10100101_2 &= 1\times 2^7 + 0\times 2^6 + 1\times 2^5 + 0\times 2^4 + \\
&\quad\ 0\times 2^3 + 1\times 2^2 + 0\times 2^1 + 1\times 2^0 \\
&= 128 + 32 + 4 + 1 \\
&= 165_{10}
\end{aligned}
$$

Bitwise operators work directly on bits:

AND:
```
  10110
& 10011
-------
  10010
```

OR:
```
  10110
| 10011
-------
  10111
```

XOR:
```
  10110
^ 10011
-------
  00101
```

Increment/Decrement Operators

```
a = a + 1; /* Common operation */
a += 1;    /* One shorthand */
a++;       /* Even more succinct */

for (i = 0 ; i < 10 ; i++) {  /* Very common idiom */
  /* i = 0, 1, 2, ..., 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

```
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

```
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

```
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

```
/* 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;
}
```

```
/* 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;
}
```

Arrays

```
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 */
a[3] = b[1]; /* a[3] = 3 */
b[3] = 42;
b[4] = 18;   /* BAD: only b[0] .. b[3] */

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" */
```

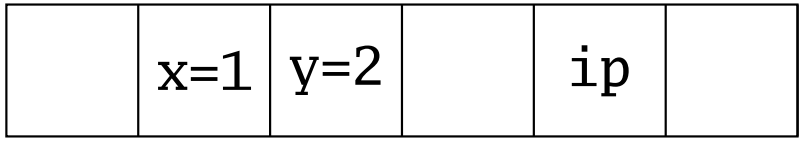
Structs

```
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

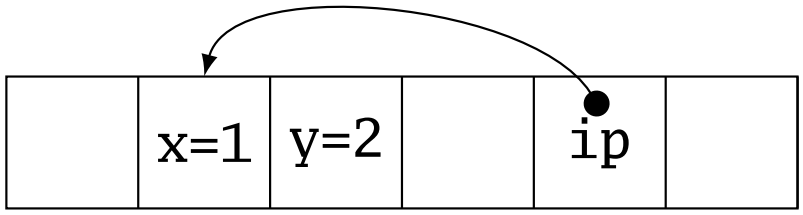
```
int num_calls = 0;  /* global variable */

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




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

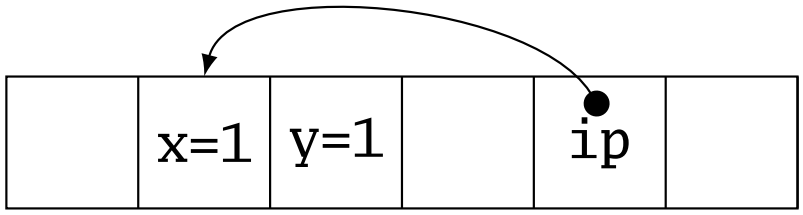
Pointers




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

```
ip = &x;
```

Pointers

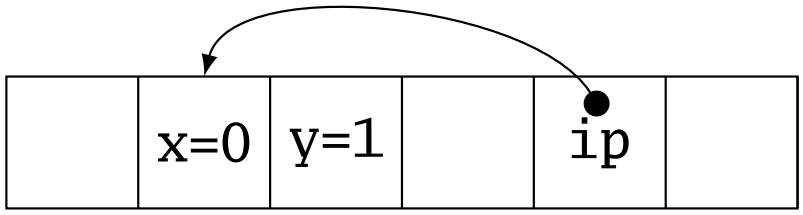



```
int x = 1, y = 2;
int *ip;
```

```
ip = &x;
```

```
y = *ip;
```

Pointers




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

```
ip = &x;
```

```
y = *ip;
```

```
*ip = 0;
```

Pointers

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

Does this work?

Pointers

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

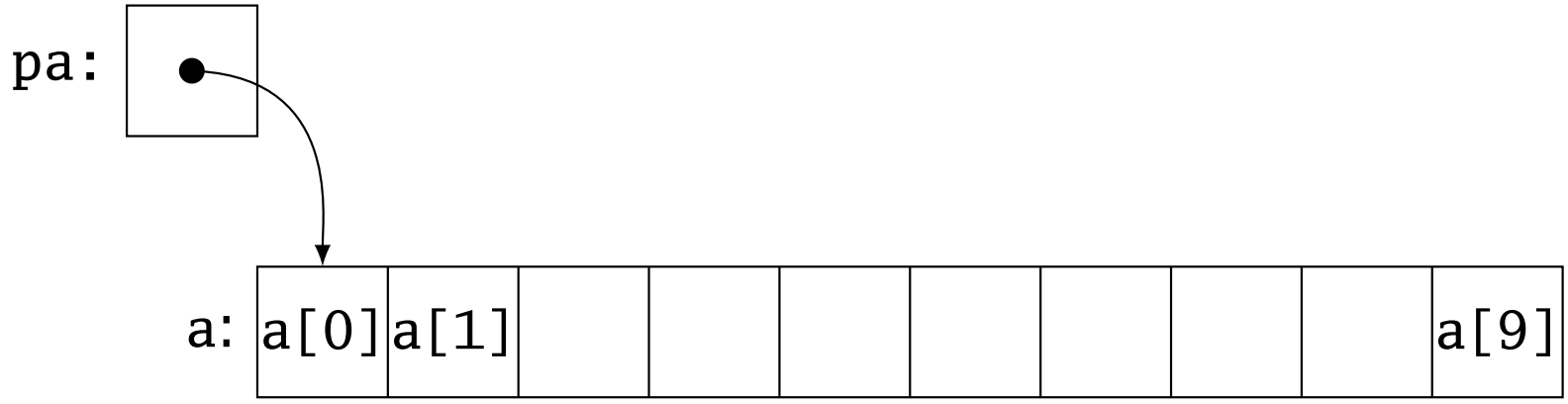
Does this work?
Nope.

```
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 */
}
```

Arrays and Pointers

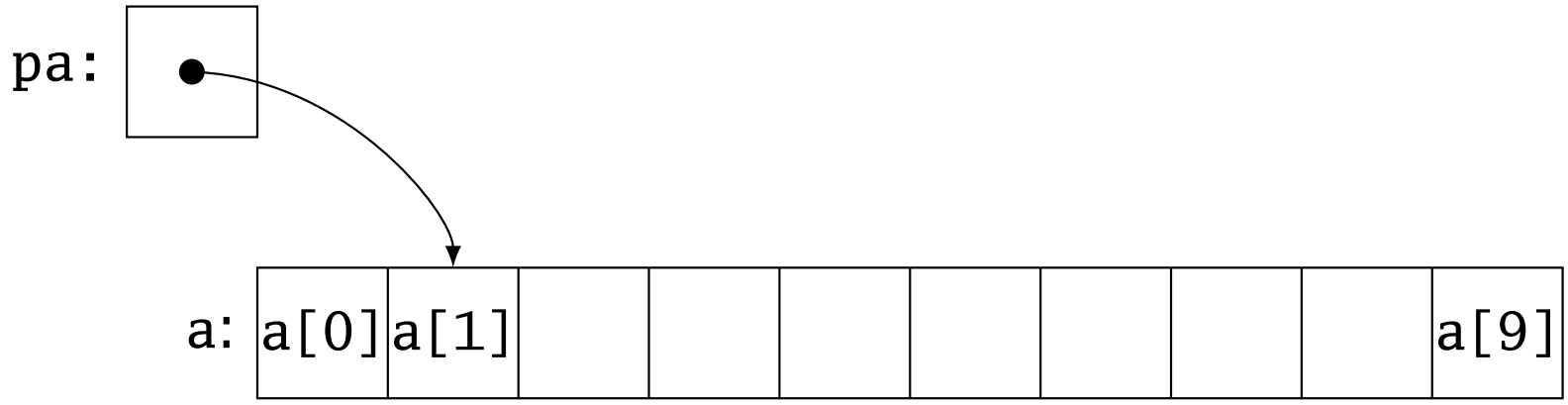

```
int a[10];
```

Arrays and Pointers



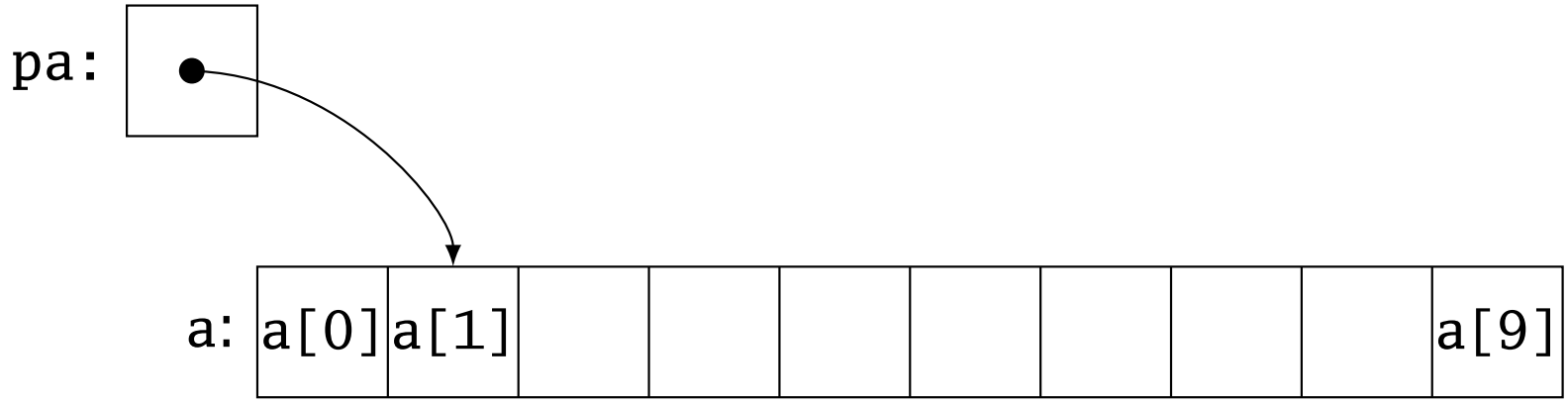

```
int a[10];
int *pa = &a[0];
```

Arrays and Pointers




```
int a[10];
int *pa = &a[0];
pa = pa + 1;
```

Arrays and Pointers

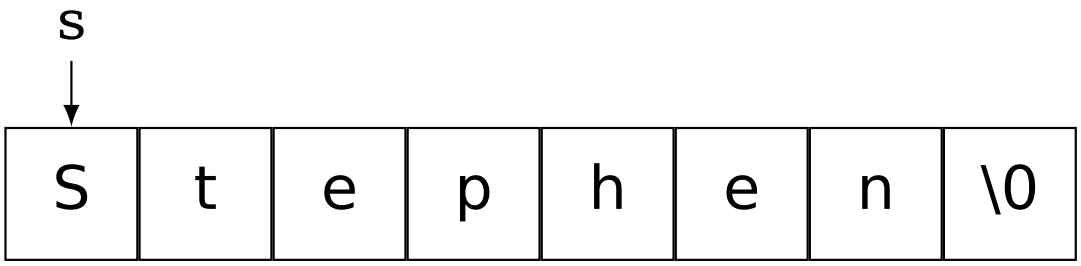



```
int a[10];
int *pa = &a[0];
pa = pa + 1;
pa = &a[1];
```

Pointers and Structs

```
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

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

int main() {
  bar();
}

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

file2.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

```
#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

```
#include "myfiles.h"

char a[] = "Hello";

int main() {
  bar();
}

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

file2.c

```
#include "myfiles.h"

static char b[6];

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