The C Programming Language

Introduction

- *C is a general-purpose programming language*
- *C provides the fundamental control-flow constructions*
- *C is a relatively "low-level" language*
- *C provides no operations to deal directly with composite objects*
- *C offers only straightforward, single-thread control flow*
- *C is independent of any particular machine architecture*
- *Some of C operators have the wrong precedence*
- *Some parts of the C syntax could be better*

Chapter 1. A Tutorial Introduction

Let us begin with a quick introduction to C

Writing a program in C to print the words:

hello, world

In C, the program to print ”hello, world” is:

```
#include <stdio.h>
main( )
{
   printf (“hello, world\n”);
}
```

include information about standard library

main function with no arguments

statements of main are enclosed in brace

call library function named printf

It’s easy!

The program would be written:

```
#include <stdio.h>
main()
{
    printf(“hello, “);
    printf(“world”);
    printf(“\n”);
}
```

【example】Calculate 1+2+3+ …… + 100

- How to calculate a+b (if a=1,b=2)

```
main()
{   int a,b, sum ;
    a= 1;  b= 2;  sum=0;
    sum = a+b;
    printf("%d\n", sum);
}
```

variables decleared before used

- How to calculate a+b+c (if a=1,b=2,c=3)

```
main()
{   int a,b,c, sum ;
    a= 1;  b= 2;  c= 3;  sum=0;
    sum = a+b;
    sum =sum+c;
    printf("%d\n", sum);
}
```

Understand?

Let me see.

【example】Calculate 1+2+3+ …… + 100

- How to calculate 1+2+3+……+100

```
main()
{
        int i,sum;
        i = 1;sum=0;
        while (i <= 100) {
                sum = sum+ i;
                i=i+1;
        }
        printf("%d\n", sum);
}
```

It's easy too!

If a,b inputted from keyboard with different values ?

- How to calculate a+b (if a,b inputted)

```
main()
{ int a,b, sum ;
   scanf("%d %d",&a,&b);
   sum = a+b;
   printf("%d\n", sum);
}
```

input from keyboard

I can!

1.2 Variables and Arithmetic Expressions

- **In C, all variables must be decleared before they are used.**
  - ***Formats:***

    type variables
  - ***Examples***

    int fahr, celsius;
    int lower, upper, step;
    float total;

- **In C, an expression is composed with:**
  - *constants*
  - *variables*
  - *functions*
  - *operators*

  Examples:

  fahr=fahr+step

1.2 Variables and Arithmetic Expressions

Program Examples

Fahrenheit	Celsius
0	-17
20	-6
40	4
60	15
80	26
100	37
120	48
140	60
160	71
180	82
200	93
220	104
260	126
280	137
300	148

```
Include <stdio.h>
    /* printf Fahrenheit-Celsius table
        for fahr=0,20,40,…,300 */
main()
{
    int fahr, celsius;
    int lower,upper,step;
    lower=0;     /*lower limit of T table*/
    upper=300;   /*upper limit*/
    step=20;     /*step size*/
    fahr=lower;
    while(fahr<=upper) {
          celsius=5*(fahr-32)/9;
          printf("%d\t%d\n", fahr,celsius);
          fahr=fahr+step;
    }
}
```

1.2 Variables and Arithmetic Expressions

The ***printf*** useful format:

- **%d** **print as decimal integer;**
- **%6d** **print as decimal integer, as at least 6 characters wide;**
- **%f** **print as floating point;**
- **%6f** **print as floating point, as at least 6 characters wide;**
- **%.2f** **print as floating point, 2 characters after decimal point;**
- **%6.2f** **print as float, at least 6 wide and 2 characters after decimal point;**
- **%o** **print as octal;**
- **%x** **print as hexadecimal;**
- **%c** **print as a character;**
- **%s** **print as character string;**
- **%%** **print % itself**

1.3 The FOR statement

Rewrited program of temperature converter using FOR:

```
#include <stdio.h>

                        /* print Fahrenheit-Celsius table */
main()
{
      int fahr;
      for (fahr=0; fahr<=300; fahr=fahr+20)
        printf ("%3d %6.1f\n", fahr, (5.0/9.0)*(fahr-32));
}
```

1.4 Symbolic Constants

Symbolic Constants is a particular string of characters.

Format:

#define *name* replacement-text

Function:

Any occurrence of name will be replaced by the corresponding replacement-text.

Examples:

```
#define LOWER 0     /* lower limit of table */
#define UPPER 300   /*UPPER limit of table */
#define STEP 20     /*step limit of table  */
                    /* print Fahrenheit-Celsius table */
main()
{
        int fahr;
        for (fahr=LOWER; fahr<=UPPER; fahr=fahr+STEP)
        printf ("%3d %6.1f\n", fahr, (5.0/9.0)*(fahr-32));
}
```

1.5 Character Input and Output

Important View:

In C, the model of Input & Output are supported by the standard library, and NOT the statements of C. This is very different of PASCAL.

Tow simplest I/O functions:

.getchar() ——read on character at a time from text stream

c=getchar();

.putchar() ——write one character at a time from text stream

putchar(c);

1.5 Character Input and Output

- File Copying *Algorithm*

read a character
while(character is not end-of-file indicator)
output the character just read
read a character

Program:

```
#include <stdio.h>
        /* copy input to output; 1st version*/
main()
{
    int c;
    c=getchar();
    while(c!=EOF){
        putchar(c);
        c=getchar();
    }
}
```

1.5 Character Input and Output

- File copying program (2nd version)

```
#include <stdio.h>
/* copy input to output; 2nd version*/
main()
{
        int c;
        while((c=getchar())!=EOF)
                putchar( c);
}
```

NOTE:

c=getchar()!=EOF
is eauivalent to
c=(getchar()!=EOF)

1.5 Character Input and Output

- Character Counting
- Version 1

```
#include <stdio.h>
main()
{
      long nc;
      nc=0;
      while(getchar()!=EOF)
         ++nc;
      printf("%ld\n",nc);
}
```

Version 2

```
#include <stdio.h>
main()
{
      double nc;
      for(nc=0;getchar()!=EOF;++nc)
         ;
      printf("%.0f\n",nc);
}
```

++ means increment by one.

++nc → nc=nc+1

1.5 Character Input and Output

Line Counting

```
#include <stdio.h>
                    /* count lines in input */
    main()
    {
          int c, nl;
          nl=0;
          while(( c=getchar())!=EOF)
                    if(c==‘\n’)
                    ++nl;
                    printf(“%d\n”,nl);
    }
```

1.5 Character Input and Output

Word Counting: count lines, words and characters in input

```
#include <stdio.h>
#define IN 1     /*inside a word */
#define OUT 0  /*outside a word */
main()
   {     int c, nl, nw, nc, state;
         state=OUT;
         nl=nw=nc=0;
         while((c=getchar())!=EOF){
         ++nc;
         if(cc== '\n')              ++nl;
         if(c==' '|| c=='\n'|| c=='\t')       state=OUT;
         else if(state==OUT)  {
                state=IN; ++nw; }
          }
         printf("%d %d %d\n",nl,nw,nc);
}
```

1.6 Arrays

Array Example: To count digits, white spaces, others.

```
#include <stdio.h>
main()
{
        int c,I,nwhite,nother;
        int ndigit[10];
        nwhite=nother=0;
        for(i=0;o<10;++i)
        ndigit[i]=0;
        while((c=getchar())!=EOF)
                if(c>='0' && c <='9')    ++ndigit[c-'0'];
                else if(c==' ' && c =='\n'|| c=='\t')
                        ++nwhite;
                else     ++nother;
        printf("digits=");
        for(i=0,i<10;i++)       printf ("%d", ndigit[i]);
        printf(", white space=%d, other=%d\n", nwhite,
nother);
}
```

1.7 Functions

Function definition form:

return-type function-name (parameter declarations, if any)

{

declarations

statements

}

1.7 Functions

Example: call n-th power.

```
#include<stdio.h>
int power(int m,int n);
main()
{
        int i;
        for(i=0;i<10;i++)
            printf("%d %d %d\n", i, power(2,i),
power(-3,i) );
        return 0;
}
/* power: raise base to n-th power: n>= 0 */
Int power (int base, int n)
{
        int i, p;
        p=1;
        for(i=1; i<= n; ++i)    p=p* base;
        return p;
}
```

1.7 Functions

```
/* power: raise base to n-th power; n >=0 */
/*        (old-style version                  */

power( base, n)
int base, n;
{
        int i, p;
        p=1;
        for(i=1;i<=n;++i)
                p=p *base;
        return p;
}
```

1.8 Arguments——call by Value

In C, all function arguments are passed *"by value"*

```
/* power: raise base to n-th power; n>=0; version 2*/
int power (int base, int n)
{
   int p;
   for(p=1;n>0;--n)
         p=p* base;
   return p;
}
```

1.9 Character Arrays

Example: reads a set of text lines and prints the longest

Algorithm:

```
while (there's another line)
      if(it's longer than the previous longest)
            save it
            save its length
print longest line
```

Program:

```
#include <stdio.h>
#define MAXLINE 1000  /*maxinum input line size */
int getline (char line[ ], int maxline);
void copy(char to[ ],  char from[ ]):
main()
{
            int  len, max;
            char line [MAXLINE], longest [MAXLINE];
            max = 0;
            while(( len = getline (line,  MAXLINE)) > 0
                  if(len > max)
                        {max = len; copy (longest, line) ;}
                  if(max>0)  /* there was a line */
                        printf("%s", longest);
                  return 0;
}
```

1.9 Character Arrays

```
/* getline: read a line into s, return length */
int getline(char s[],int lim)
{
    int c, i;
    for(i=0; i<lim-1&&(c=getchar())!=EOF && c!='\n';++i)
        s[i]=c;
    s[i]='\0';
    return i;
}
/* copy: copy 'from into 'to'; assume to be big enough */
void copy(char to[], char from[])
{
    int i=0;
    while ((to[i]=from[i]) != '\0')
        ++i;
}
```

Any String is Terminated with '\0'

1.10 External Variables and scope

If the program is in several source file, and a variables is defined in file1 and used in file2 and file3, then extern declarations are needed in file2 and file3 to connect the accurences of the variable.

file1.c

```
#include <stdio.h>
float rate;
main()
{
      int number;
      float total(int n);
      number =10;
      rate = 0.98;
      printf (“total =%f, number = %d\n”,
            total (number), number);
}
```

file2.c

```
float total (int num)
{
      extern float rate;
      return rate *num;
}
```

Chapter 2: Types, Operators, and Expressions

2.1 Variable Name

- letters (include '_') and digits, begin with letter.
- Lower case and upper case letters are distinct
- Keywords like if, else, int float, ect, are reserved.

2.2 Data Types and Sizes

2.2 Data Types and States

basic data types in C:

char 字符类型

int 整型

可加 long, short:

short int sh; or short sh;

long int counter; or long counter;

float 浮点型

double 双精度浮点型

对char, int可加 unsigned; unsigned int i;

2.3 Constants

int: 123

long: 12345678l, 12345678L

float(double): 123.4 1.2e-2

char: ‘a’ , ‘4’, ‘\013’, ‘\n’

string constant : “ hello, world”

NOTICE!

‘h’+’e’+’l’+’l’+’o’+’,’+’w’+’o’+’r’+’l’+’d’+’\0’

strlen(s)

```
int strlen(char s[])
{
        int i;
        i=0;
        while(s[i] != ‘\0’) ++i;
        return i;
}
```

2.3 Constants

int: 123

long: 12345678l, 12345678L

float(double): 123.4 1.2e-2

char: ‘a’ , ‘4’, ‘\013’, ‘\n’

string constant : “ hello, world”

enumeration constant (枚举常量）：

```
enum boolean {NO, YES};
                    /* NO=0, YES=1 */
enum weeks {MON=1,TUE, WED, THU, FRI, SAT, SUN}
```

2.3 Constants

int: 123

long: 12345678l, 12345678L

float(double): 123.4 1.2e-2

char: ‘a’ , ‘4’, ‘\013’, ‘\n’

string constant : “ hello, world”

enumeration constant (枚举常量）：

symbolic constant

#define MAXLINE 1000

#define NO 0

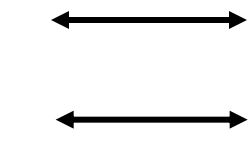
#define YES 1

/* NO “;”, here */

2.4 Declarations

type var1, var2, …, varN;

```
int lower, upper, step;
char c, line[1000];
```



```
int lower;
int upper;
int step;
char c;
char line[1000];
```

a variable may also be initialized in its declaration, e.g.;

```
char esc = '\\';
int i=0;
int limit = MAXLINE +1;
```

the qualifier const can be appied to the declaration

of any variable to specify that its value will not be changed.

```
const double e=2.71828;
const char msg[]="warning:";
```

2.5 Arithmetic Operators

artithmetic operators: +,-,*,/,%

%: produces the remainder(求余), can not be applied to float, double

/: int/int => int;

17/5 => 3;

17./5 => 3.4

```
if((year %4 ==0 && year %100 !=0) || year % 400==0)
        printf("%d is a leap year\n", year);
else printf("%d is not a leap year\n", year);
```

precedence:

*, /, %	**high**
+, -	**low**

2.6 relational and Logical Operators

The relational operators: >, >=, <, <=, ==, !=

Precedence:

- *, /, %
- +, -
- >, >=, <, <=
- ==, !=
- ||

logical operators: && (与）, ||（或), !(非)

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

(c=getchar())!= '\n'

!valid < == > valid==0

result of logical expression: true ----1; false----0;

当作逻辑判断时：非0 ----true; 0 ---flase;

2.7 Type Conversions

char<short int<int<unsigned<long<unsigned long<float<double

Example1:

```
int atoi(char s[])
{       int I, n;
        n=0;
        for(i=0;s[i]>='0' && s[i]<='9'; ++i)
                n=10*n + (s[i]- '0');
        return 0;
}
```

Example2:

```
int lower(int c)
{       if(c>='A' && c <= 'Z')
                return c + 'a' –'A';
        else return c;
}
```

2.7 Type Conversions

char<short int<int<unsigned<long<unsigned long<float<double

type conversions take place in:

- expression with multi-kinds of data
- assignments
- argument passing (function call)
- explicit type conversion (forced);

(type_name) expression

```
unsigned long int next=1;
int rand(void)
{       next = next * 1103515245 + 12345;
        return (unsigned int)(next/65536) % 32768;
}
void srand(unsigned int seed)
{       next=seed;
}
```

2.8 Increment and Decrement Operators

(increment operator) ++: adds 1 to its operand(自增）

(decrement operator) --: substract 1 from its operand(自减）

```
int i=3；
        i++；  /* i=i+1 */
```

i++ and ++i are different (also i--, --i);

If n is 5,then

```
    x=n++;          /* n=6,x=5 */
```

but: x=++n; /* n=6,x=6 */

```
void squeeze(char s[], int c)
{   int i, j;
    for( i=j=0; s[i]!='\0'; i++)
            if(s[i] !=c) s[j++]=s[i];
    s[j]='\0';
}
```

```
if (s[i]!=c) { s[j]=s[i];j++;}
```

2.8 Increment and Decrement Operators

- **Example 2:**
  - *if (c== '\n') { s[i]=c; ++i;}*
  - *if (c== '\n') s[i++] =c;*
- **Example 3:**

```
/* stract: concate t to end of s; s must be big enough */
void strcat(char s[], char t[])
{   int i, j;
    i=j=0;
    while (s[i] !='\0') i++;
    while ((s[i++] = t[j++]) !='\0');
}
```

2.9 Bitwise Operators

a	b	a&b	a|b	a^b	~a
0	0	0	0	0	1
0	1	0	1	1	1
1	0	0	1	1	0
1	1	1	1	0	0

- **Operators:**
  &: bitwise AND
  |: bitwise inclusive OR
  ^: bitwise execlusive OR
  <<: left shift
  >>: right shift
  ~: one's complement (unary)
  distinguish &/: from &&/||:
  x=1; y=2;
  x&y == > 0;
  x&&y == >1;
  shift operatirs << and >>:
  <<: fill with 0;
  >>: fill with 0 (logical shift) or with sign bit (artithmetic shift)

Examples:

- ☆ Bitwise AND (&)
- 3 & 5 = ?
- 3=>0000 0011
- 5=>0000 0101
- & 0000 0001 (1)
- i.e., 3 & 5 = 1
- & is often used to mask off some set of bits, e.g.:
- n = n & 0177; n xxx…xxx x??? ????
- &
- 0177 000…000 0111 1111
- ⇩
- n 000…000 0??? ????

- ☆ Bitwise inclusive OR (|)
- 060 | 017 = ?
- 060=> 0011 0000
- 017=> 0000 1111
- | 0011 1111 (077)
- i.e.,060 | 017 = 077
- | is used to turn bits on:
- x = x | SET_ON
- ☆ Bitwise exclusive OR (^)
- 规则：参加运算的两个相应位相同，则结果为0， 相异则为1。
- 0011 1001 (071)
- (^) 0010 1010 (052)
- 0001 0011 (023)
- i.e., 071^052 = 023

- ☆ One's complement (~)
- The unary operator ~ yields the one's complement of an integer; that is, it converts each 1-bit into a 0-bits and vice versa.
- 025= 0000 0000 0010 0101
- ~025= 1111 1111 1101 1010
- i.e., ~025 = 0177732 (**NOT** -025)
- Example: x = x & ~077 sets tha last six bits of x to zero.
- Note: x & ~077 is independent of word length. (cf:x&0177700)

- ☆ Left shift (<<)
- The x << n shifts the value of x left by n positions, filling vacated bits with zero.
- char a;
- a binary a << 1 a << 2
- 64 01000000 0 10000000 01 00000000
- 127 01111111 0 11111110 01 11111100
- i.e., 64<<1 = 0x80, 64<<2 = 0, 127<<1 = 0xfe, 127<<2 = 0xfc

- ☆ Right shift (>>)
- Right shifting an **unsigned** quantity always fills vacated bits with zero;
- Right shifting an **signed** quantity will fill with sign bits (arithmetic shift 算术移位) on some machines and with 0-bits (logical shift 逻辑移位) on others.
- a: 1001 0111 1110 1101
- a>>1: 0100 1011 1111 0110 1 (logical shift)
- a>>1: 1100 1011 1111 0110 1 (arithmetic shift)
- ☆ Distinguish &/|(bitwise ops) from &&/|| (logical ops).
- x = 1, y = 2
- x & y => 00000001 & 00000010 => 00000000
- x && y => 1

- ☆ Precedence:
- “~” = “&” > “<<” = “>>” > “^” > “|”

2.9 Bitwise Operators

- Example :

```
/* getbits: get n bits from position p */
unsigned getbits(unsigned x, int p, int n)
{
        return (x>> (p+1-n)) & ~(~0 << n);
}
```

See chap2_1.doc

- p 0
- n p+1-n
- x
- p
- n
- x>>(p+1-n) xx.....xx ???.....???
- ~(~0<<n) 00.....00 111.....1111
- &)
- 00.....00 ???.....???

2.10 Assignment Operators and Expressions

- assignment operators:

  =, +=, -=, *=, /=, %=, <<= , >>=, &=, ^=,|=

expr1 op= expr2 <==> expr1 = (expr1) op (expr2)

Example:

```
/* bitcount : count 1 bits in x */
int bitcount(unsigned x)
{       int b;
        for(b=0; x!=0; x>>=1)
                if(x&01)     b++;
        return b;
}
```

assignment in expression:

```
while (( c= getchar()) !=EOF) …
```

2.11 Conditional Expressions

expr1 ? expr2 : expr3

example: → if(a>b) z=a; else z=b;

```
z=(a>b)? a:b;
```

example 2:

```
for(i=0; i< n; i++)
  printf("%6d%c", a[i],(i%10==9|| i==n-1)? '\n' : ' ');
/* print an array, 10 per lin */
```

2.12 Precedence and Order of Evaluation

- **Operators Associativity**

() [] -> .	
! - ++ -- + - * & sizeof	right to left
* / %	
+ -	
<< >>	
== !=	
&	
^	
|	
&&	
||	
?:	right to left
= += -= *= /= %= ^= |= <<= >>=	right to left

2.12 Precedence and Order of Evaluation

- **NOTICE:**

  x= f() +g():

  1. evaluate f() -- > evaluate g();
  2. evaluate g() -- > evaluate f();

  Example:

  i=1;

  x=i + ++i;

  x have different results with different compliers (x=3 or 4)

Chapter 3. Control Flow

- **3.1 Statements and Blocks**

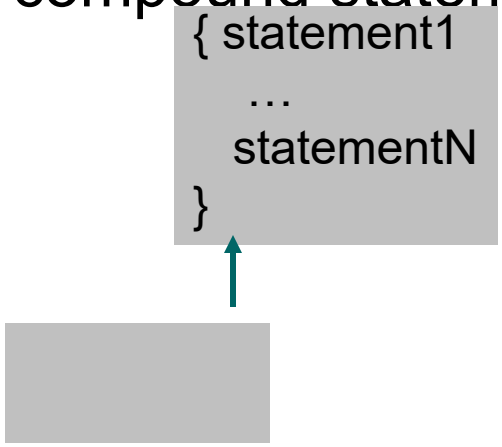
  .expression +; === > statement

  x=0;

  i++;

  printf(…);

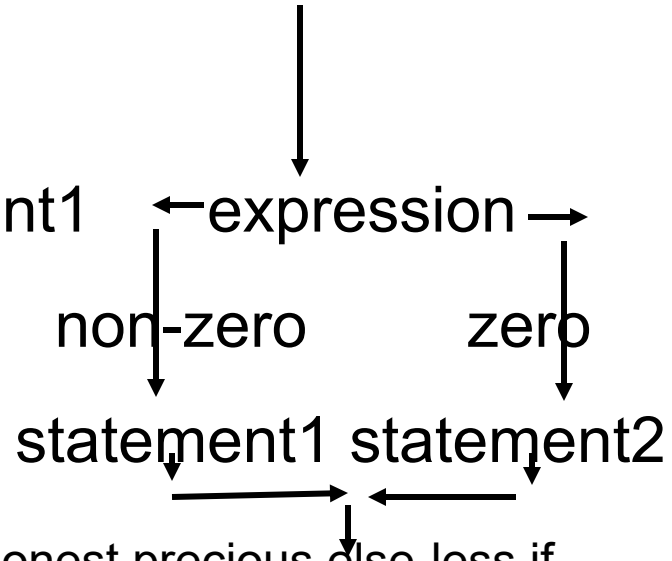
  compound statement (block):



3.2 If-else

- syntax:

```
if(expression) statement1
else statement2
```



rule: associating the else with the clonest precious else-less if.

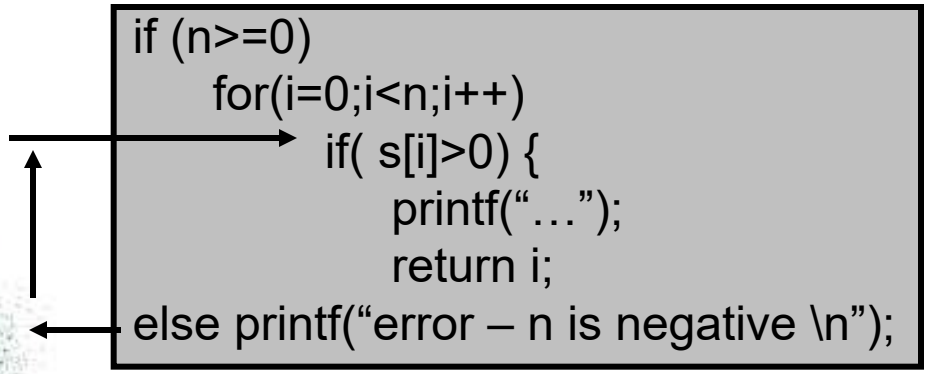
```
if (n>0)
   if( a>b) z=a;
else z=b;
```



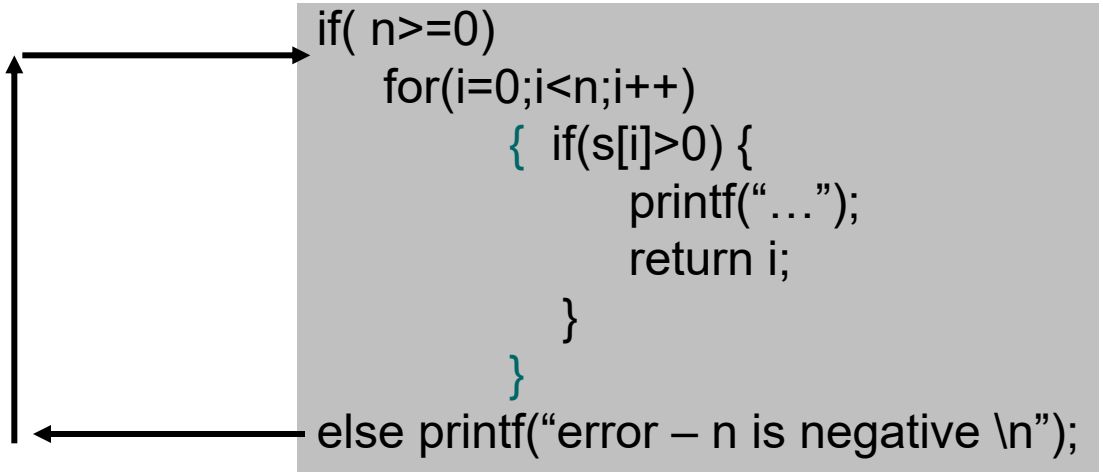
```
if( n>0)
  { if (a>b) z=a;
    else z=b;  }
```

3.2 If-else

- Example:



```
if (n>=0)
      for(i=0;i<n;i++)
            if( s[i]>0) {
                  printf("…");
                  return i;
else printf("error – n is negative \n");
```



```
if( n>=0)
     for(i=0;i<n;i++)
           {  if(s[i]>0) {
                 printf("…");
                 return i;
              }
           }
else printf("error – n is negative \n");
```

3.3 Else-if

if (expression) statement

else if (expression) statement

else if (expression) statement

else statement

```
/* binsearch: find x in v[0]<=v[1]<=…<=v[n-1] */
int binsearch(int x ,intv[], int n)
{  int low ,high,mid;
   low =0;
   high=n-1;
   while(low <=high) {
            mid=(low+high)/2;
            if( x< v[mid]) high =mid-1;
            else if (x>v[mid]) low = mid+1;
            else return mid;
    }
    return -1;
}
```

see chap2_2

3.4 Switch

syntax: see chap2_2 2.3

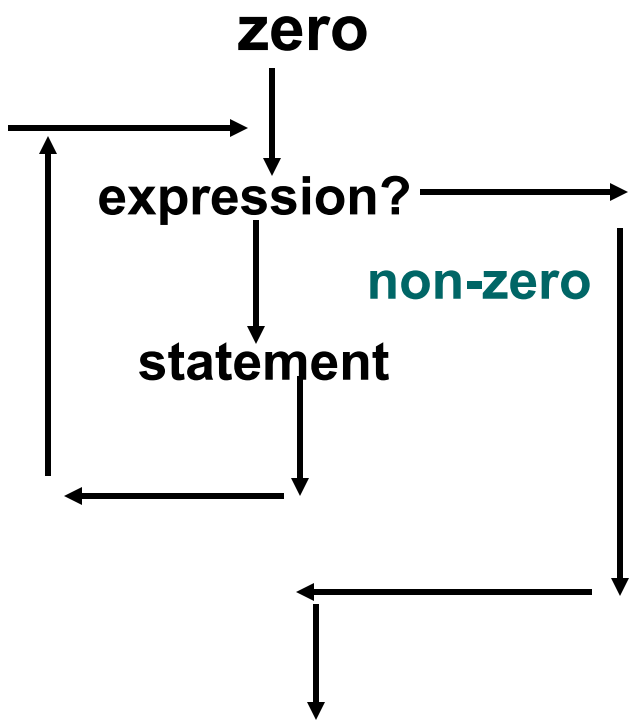
example:

```
#include <stdio.h>
main() /* count digits, white space, others */
{   int c,I,nwhite, nother, ndigit[10];
        nwhite = nother=0;
        for(i=0;i<10;i++) ndigit[i]=0;
        while (( c=getchar())!=EOF ){
            switch( c)  {
                    case ‘0’: case ‘1’: case ’2’: case ’3’: case ‘4’:
                     case ‘5’: case ‘6’: case ’7’: case ’8’: case ‘9’:
                                ndigit[c-’0’]++;  break;
                    case ‘ ‘: case ‘\n’: case ‘\t’ :
                                nwhite++;     break:
                    default:  nother++;   break:
        }
        printf(“digits = “);
        for( i=0,i<10;i++) printf(“ %d”, ndigit[i]);
        printf(“, white space = %d, other = %d\n”, nwhite, nother);
        return 0;
}
```

3.5 Loops-----While and For

- while:
  - *while (expression)*
    statement
  - *For*

```
for
(expr1;expr2;expr3)
        statement
```




```
expr1;
while (expr2) {
        statement
        expr3;
}
```

inifinte loop:

```
for(;;)  {……}
```

processing the first n element of an array

```
for(i=0;i<n;i++)
    …
```

3.5 Loops-----While and For

- **Example 1:**

```
#include <ctype.h>
/*atoi: convey s to integer; version 2 */
int atoi(char s[])
{    int I,n, sign;
     for(i=0;isspace(s[i]);i++; /*skip white space */
     sign = (s[i] == '-')? -1:1;
     if( s[i] == '-')? -1:1;
            i++;
     for(n=0; isdigit(s[i]);i++)
            n=10*n +(s[i]- '0');
     return  sign *n ;
}
```

3.5 Loops-----While and For

- ***Example 2:*** ***see chap2_2 2.4***

```
/* shellshort: sort v[0]…v[n-1] into increasing order */
void shellshort(int v[],int n)
  {     int gap,i,j,temp;
        for(gap=n/2;gap>0;gap/=2)
                for(i=gap;i<n;i--)
                        temp=v[j];
                        v[j]=v[j+gap];
                        v[j+jap]=temp;
                }
  }
```

3.5 Loops-----While and For

- ***Example 2:***

```
/* shellshort: sort v[0]…v[n-1] into increasing order */
   void shellshort(int v[],int n)
     {        int gap,i,j,temp;
              for(gap=n/2;gap>0;gap/=2)
                       for(i=gap;i<n;i++)
                           for( j=i-gap;j>=0 && v[j]>v[j+gap];j-=gap) {
                                    temp=v[j];
                                    v[j]=v[j+gap];
                                    v[j+gap]=temp;
                           }
     }
```

```
for(i=1;i<n;i--)
   for  (j=j-1;j>=0&&v[j]>v[j+1];j-=1 {
         temp=v[j];
          v[j]=v[j+1];
         v[j+1]=temp;
}
```

3.5 Loops-----While and For

- ***Example 3:***

```
#include <string.h>
/* reverse : reverse string s in place */
void reverse(char s[])
{     int c,i,j;
      for( i=0,j=strlen(s)-1;i<j; i++,j--)  {
                  c= s[i];
                  s[i]=s[j];
                  s[j]=c;
      }
}
```

3.6 Loops---Do-while

- syntax:

```
do
   statement
while (expression);
```

Example:

```
/* itoa: convert n to characters in s */
void itoa(int n,char s[])
{  int i,sign;
   if ((sign=n)<0 )  /*record sign */
       n=-n;
   i=0;
   do {
              s[i++] = n %10+'0';  /*get next digit */
   }   while ((n/=10)>0);  /*delete it */
  if( sign <0) s[i++] = '-';
 s[i]= '\0';
   reverse(s);
}
```

3.7 Break and Continue

- break: exit the loop

```
 /* trim: remove trailing blanks, tabs, newlines */
int trim(char s[])
{   int n;
    for(n=strlen(s)-1;n>=0;n--)
       if(s[n]!=‘ ‘ && s[n] != ‘\t’ && s[n] != ‘\n’ ) break;
    s[n+1]= ‘\0’;
    return n;
}
```

continue: cause the next iteration to begin

```
for(i=0;i<n;i++) {
    if(a[i]<0)  /*skip negative element */
       continue;
… /* do positive elements */

}
```

3.8 Goto and Labels

- syntax:

  goto label_name

  label_name: statements

  Example 1:

```
for(…)
        for(…) {
            if(disaster)
                goto error;
        }
        …
        error: clean up the mess
```

3.8 Goto and Labels

- with goto:

```
for(i=0;i<n;i++)
      for(j=0;j<m;j++)
            if(a[i]==b[j])
                  goto found;
/* didn't find any common element */
   …
found:
/* got one: a[i] == b[j] */
            …
```

without goto:

```
found =0;
for(i=0;i<n && !found; i++)
     for(j=0;j<m && !found; j++)
           if(a[i] == b[j])
                found =1;
if (found)
       /* got one: a[i] == b[j] */
       …
else
    /* didn't find any common element*/
     …
```

Examples:

- 【Example 1】把100~200之间不能被3整除的数输出。

```
main()
{
        int n;

        for (n = 100; n <= 200; n++) {
         if (n%3 == 0)                          /*  if (n%3)  */
              continue;                         /* printf("%d ", n);*/
         printf("%d ", n);
        }
}
```

【Example 2】求Sn=a+aa+aaa+...+aaa...a之值，其中a是一个数字。

- 例如：2+22+222+2222+22222（此时n=5），n和a由键盘输入。
- ☆ 算法分析：求解该题的关键是要求出每一个aaa...a(共i个a)，i = 1~n。而： i个a 与 （i-1）个a 的关系：
- 若令：s（i-1） = aaa...a，则：
- s（i） = aaaa...a = s(i-1)*10+a

- 如：22=2*10+2, 222=22*10+2, 2222=222*10+2,
- 22222=2222*10+2
- ……

```
#include <stdio.h>
main()
{       int         a, n, i, j;
        long        s, s0;
        printf("Please enter digit number a: ");
        while ((a=getchar()) < '0' || a > '9')   ;      /*输入一个数字*/
        a = a - '0';                                    /* 将字符a转换成数a */
        printf("Please enter n: ");
        scanf("%d", &n);
        s = 0L;
        for (i = 1; i <= n; i++) {
                s0 = 0L;
                for (j = 1; j <= i; j++)            /* 求s0=aaa...a(i个a) */
                        s0 = s0 * 10L + a;
                s += s0;}                           /* 累加前i个数 */
        for (i = 1; i < n; i++) {                   /*打印a+aa+...+aaa...a+ */
                for (j = 1; j <= i; j++)
                        putchar(a+'0');    /* 将数字a以字符形式打印出来 */
                printf("+");}
        for (j = 1; j <= n; j++)                    /* 打印aaa...a(n个a) */
                putchar(a+'0');
        printf("=");
        printf("%ld\n", s);
}
```

☆ Solution 2:

```
#include <stdio.h>
main()
{       int         a, n, i, j;
        long        s, s0;
        printf("Please enter digit number a: ");
        while ((a=getchar()) < '0' || a > '9')  ;       /*输入一个数字*/
        a = a - '0';                                    /* 将字符a转换成数a */
        printf("Please enter n: ");
        scanf("%d", &n);
        s = s0 = a;
        for (i = 2; i <= n; i++) {
                s0 = s0 * 10L + a;              /* 利用i-1个a计算i个a */
                s += s0;   }                        /* 累加前i个数 */
        for (i = 1; i < n; i++) {                   /*打印a+aa+...+aaa...a+ */
                for (j = 1; j <= i; j++)
                    putchar(a+'0');/* 将数字a以字符形式打印出来 */
                printf("+");}
        for (j = 1; j <= n; j++)                    /* 打印aaa...a(n个a) */
                putchar(a+'0');
        printf("=");            printf("%ld\n", s);
```

- 【Example 3】
- 一个数如果恰好是它的因子之和，这个数就称为“完数”。例如：6的因子1、2、3，而6=1+2+3，因此，6是“完数”。编程找出1000之内的所有完数，并按下面格式输出其因子：
- 6 its factors are 1,2,3
- ☆ 算法分析：求解该题的关键是求出一个数的所有因子，又因为还要打印完数的因子，所以，还必须将每个因子暂时保存起来。

☆Solution:

```
#include <stdio.h>
int    factors(int i, int fac[]);          /* 函数原型说明 */
main()
{       int          fac[1000];
        int          i, j, n, s;
        for (i = 0; i < 1000; i++) {
                    n=factors(i, fac); /*调函数factors求i的所有因子*/
                    s = 0;          /*fac 为存放因子的数组，n为个数*/
                    for (j = 0; j < n; j++)
                        s += fac[j];      /* 将所有的因子累加起来 */
                    if (i == s) {         /* 若该数i等于其所有因子之和 */
                                printf("%3d  its factors are  ", i);
                                for (j = 0; j < n; j++) {
                                            printf("%d", fac[j]);
                                            if (j != n-1)    printf(",");  }
                     }
         }
}
```

```
int   factors(int i, int fac[])
{
        int k, j;
        j = 0;
        for (k = 1; k < i; k++)
                if (i%k == 0) {/*若i能被k整除*/
                  fac[j] = k;/*保存因子k到数组fac[]中*/
                  j++;            /*因子的个数加1*/
                }
        return(n);              /*将因子的个数传回*/
}
```

Chapter 4. Function and Program Struction

- 4.1 Basics of Functions

  Form of function definition:

  return-type function-name(argument declaration)

  { declarations and statements

  }

  a minimal function: dummy(){}

  return statement:

  return expression:

  or return (expression):

4.1 Basic of Functions

- Example:

```
#include <stdio.h>
#define MAXLINE 1000  /*maximum input line length  */
int getline(char line[], int max);
int strindex(char source[], char searchfor[]);
char pattern[] = “ould”;  /*pattern to search for  */
/* find all lines matching pattern */
main()
{   char line[MAXLINE];
     int found=0;
    while(getline(line,MAXLINE)>0)
            if(strindex(line,pattern)>=0)  {
                    printf(“%s”,line);
                    found++;
            }
   return found;
}
```

4.1 Basic of Functions

```
    /*getline: get line into s,return length */
int getline(char s[], int lim)
{   int c, i;
    i=0;
    while(--lim>0 && (c=getchar()) !=EOF && c!='\n')
            s[i++] =c;
    if( c=='\n')     s[i++]=c;
    s[i]='\0';
    return i;
}
   /*strindex: return index of t in s,-1 if none */
Int strindex(char s[], char t[])
{   int i, j, k;
    for(i=0;s[i]!='\0';i++)  {
            for(j=i,k=0;  t[k]!='\0'  && s[j]==t[k];   j++,k++)     ;
            if( k>0 && t[k] =='\0')  return  i;
    }
    return -1;
}
```

4.2 Functions Returning Non-integers

(1) must declare the type of value it returns

(2) the calling routine must know that returns a non-int value.

example:

```
#include <ctype.h>
        /* atof: convert string s to double */
double atof(char s[])
{       double  val, decimal, power;
        int i,sign;

         for(i=0;isspace(s[i]); i++)  ;      /*skip white space */
        sign = (s[i] ==‘-’)? -1:1;
        if( s[i] = =‘+’ || s[i] ==  ‘-’)    i++;
           decimal = 0;  power = 1.0;
        for( val=0.0; isdigit(s[i]) || s[i]==‘.’;  i++) {
              if (s[i]!=‘.’){
                            if(decimal  ==1)   power *=10.0;
                           val=10.0*val +(s[i]-’0’);}
            else  decimal = 1;}
        return          sign *val /power;     }
```

4.2 Functions Returning Non-integers

- calling atof():

declaration (function protype)

or : atof();
in old version

```
#include <stdio.h>
#define  MAXLINE  100
main()
{       double sum, atof(char [ ]);
        char line[MAXLINE];
        int getline (char line[], int max);
        sum=0;
        while(getline(line,MAXLINE) >0)
                printf("\t%lf \n", sum+= atof(line));
        return 0;
}
```

calling

4.3 External Variables

- external variables: defined outside of any function
  and available to many functions (globally accessiable)

Example:

calculator that provides the operators +,-,*/

use reverse Polish(逆波兰) notation instead of infix(中缀).

1 2 - 4 5 + * < ==== > (1-2)*(4+5)

the main algorithm of the program:

while(next operator or operand is not end_of_file indicator)

if(number) push it

else if (operator) pop operands

do operation

push result

else if (newline) pop and print top of stack

else error

4.3 External Variables

```
#include <stdio.h>
#include <math.h>
#define MAXOP 100 /*max size of operand or operator */
int getop(char [ ]);
void push(double);
    /* reverse Polish calculator */

main()
{   int type;
    double op2;
    char s[MAXOP];
```

4.3 External Variables

```
while(( type = getop(s))!=EOF) {
        switch (type) {
                case NUMBER: push(atof(s)); break;
                case '+': push(pop() + pop());  break;
                case '*': push(pop() *pop());    break;
                case '-': op2=pop();  push(pop()-op2);    break;
                case '/': op2=pop();
                        if(op2!=0.0)     push(pop()/op2);
                        else  printf("error: zero divisor\n"); break;
                case '\n': printf("\t.8g\n", pop()); break;
              default: printf("error: unknown command %s \n", s);
                        break;
        }
    return 0;
}
```

4.3 External Variables

```
#define MAXVAL 100                  /* maximum depth of val stack */
int sp=0;                           /*next free stack position */
double val[MAXVAL];                 /*val stack */
      /* push: push f onto value stack */
void push(double f)
{   if(sp<MAXVAL) val[sp++]=f;
      else printf( ‘error: stack full,can’ t push %g\n”, f);
}
     /* pop: pop and return top value from stack */
double pop(void)
{   if(sp>0) return val[--sp];
    else { printf(“error: stack empty\n”);
           return 0.0;}
}
```

4.3 External Variables

```
#include <ctype.h>
int getch(void);
void ungetch(int);
        /* getop: get next operator or numeric operand */
int getop(char s[])
{  int     i,c;
   while ((s[0] = c= getch()) == ' ' || c== '\t');
   s[1]= '\0';
   if (!isdigit(c) && c!= '.')       return c;
   i=0;
   if( isdigit(c))      while (isdigit (s[++i] =c =getch()))  ;
   if(c=='.')           while (isdigit(s[++i]=c=getch()));  /* . OK */
   s[i] = '\0';   /*  last getch is not digit    */
    if (c!=EOF)     ungetch(c);
   return     NUMBER;
}
```

```
#define BUFSIZE 100
char buf[BUFSIZE]; /*buffer for ungetch */
int bufp=0;          /* next free position in buf */
int getch(void)      /* get a character */
{  return (bufp >0) ? buf[--bufp] : getchar();
}
void ungetch(int c) /*push character back on input */
{ if (bufp >= BUFSIZE)  printf(“ungetch: too many
   characters\n”);
   else buf[bufp++]=c;
}
```

4.4 Scope Rules

- scope of a name (variable, function, ect); SEE CHAP2_4 4.8

  the part of the program within which the name can be used.

- scope of an automatic variable :

  the function in which the name is declared

- scope *of an external variable or a function:*

  from the point at which it is declared to the end of the file

  if an external variable is to be referred to before it is defind

  or a name is defind in a different source file:

  an extern declaration is mandatory

In file1:

```
extern int sp;
extern double val[];
void push(double f) {…}
void pop(void) {…}
```

In file2:

```
int sp=0;
double val[MAXVAL];
```

Discussion

- **§4.8 局部变量和全局变量**
- **4.8.1 局部变量**
- ☆ 在一个函数内部定义的变量是内部变量，它**只在本函数范围内有效**。

```
float f1(int a)                                   /* 函数f1 */
{
        int b, c;                                  a 、b、c有效
        ……
}
char f2(int x, int y)              /* 函数f2 */
{
        int a, b;          x、y、a、b有效
        ……
}
main()                                                                          /* 主函数 */
{
        int m, n;                                                       m、n有效
        ……
}
```

【说明】

1、主函数main中定义的变量（m、n）也只在主函数中有效；主函数也不能使用其它函数中定义的变量。

2、不同函数中可以使用相同名字的变量，它们代表**不同**的对象，互不干扰。

如：在f1函数中定义了变量b，在f2函数中也定义了变量b，它们**占据不同的内存单元**。

3、形式参数也是局部变量。

4、可以在复合语句中定义变量，这些变量只在本复合语句中有效。

```
main()
{
        int a, b;
        ……
        {
                int c;
                    a、b在此范围内有效
                c = a + b;      c在此范围内有效
                ……
```

§4.3 函数参数和函数的值

4.3.1 形式参数和实际参数

☆ 在**定义**函数时，函数名后面括弧中的变量名称为“**形式参数**”。

☆ 在**调用**函数时， 函数名后面括弧中的表达式称为“**实际参数**”。

【Example】

```
#include <stdio.h>
main()
{
        int a, b, c;
        scanf("%d%,%d", &a, &b);
        c = max(a, b);
        printf("Max is %d\n", c);
}
int max(int x, int y)                /* 定义有参函数max */
{
        int z;
        z = x > y ? x : y;
        return(z);
}
```

☆ 关于形参与实参的说明：

1、形参变量是动态地占据内存的：在未出现函数调用时，它们并不占内存中的存储单元，只有在发生函数调用时函数max中的形参才被分配内存单元。在调用结束后，形参所占的内存单元也被释放。

2、实参可以是常量、变量或表达式。如：

```
                                                max(3, a+b);
```

        但要求它们有确定的值。在调用时将实参的值赋给形参变量。

3、在被定义的函数中，必须指定形参的类型。

4、实参与形参的类型应一致。

5、C语言规定：实参对形参的数据传递是“值传递”，即单向传递，只有实参传给形参，而不能由形参传回来给实参。在内存中，**实参单元与形参单元是不同的单元**，形参变量值的改变不影响对应的实参的值：

```
int max(int x, int y)                /* 定义有参函数max */
{
        int z;
        z = x > y ? x : y;
        x = x * 5;
        y = y * 5;
```

4.5 Header Files

- place the definitions and declarations shared among the files in a ***header file.***
- ***example:***

calc.h:

```
#define NUMBER ‘0’
void push(double);
int getop(char []);
int getch(void);
void ungetch(int);
```

stack.c:

```
…
```

main.c:

```
#include <stdio.h>
#include <math.h>
#include “calc.h”
#define MAXOP 100
main() {
 …
}
```

getch.c

```
…
```

getop.c:

```
#include <stdio.h>
#include <ctype.h>
#include “calc.h”
getop() {
     …
}
```

4.6 Static Variables

- **static:** SEE CHAP2_4

(1) applied to an external variables or function:

limits the scope of that object to the rest of the source file, the name is invisiable outside the file.

```
static char[BUFSIZE]; /* buffer for ungetch */
int getch(void) {…}
void ungetch(int c) {…}
```

(2) applied to an internal variable:

the scope is the function (as automatic variable,but it remain in existence as the program (not the function) is activated.

```
void Example()
{    static i=1;
     printf("%d times\n", i++);
}
```

```
main()
{   Example();
    Example();
    Example();
}
```

1 times
2 times
3 times

static variables is initialized only the first time function is entered

4.7 Register Variables

- **register:** advises the complier to place the variable in registers, in order to result in smaller and faster programs.
- **format**

```
register int x;
register char c;
```

example:

```
f(register unsigned m, register long n)
{    register int i;
     …
}
```

notice:

- *register declaration can only be applied to automatic variable and to the formal parameters of a function*
- *only a few variables can be kept in registers, excess declaration will be ignored.*
- *can not take the address of a register variable*
- *there are restrictions on types of register variables.*

4.8 Block Structure

- **block: {……}**
- variable can be declared in a block (follow the left brace),, the scope of the variable is the block and remain in existence until matching the right brace.

```
if(n>0) {
    int i;     /*declare a new i */
    for  (i=0;i<n; i++)
    ….
}
```

→ the scope of “i”

the variable in inner scope will hide variables in outer scope of the same name.

inner first →

```
int x,y;
f(double x)
{   double y;
    …
     x=y+1;
    …
}
g( )
…
```

4.9 Initialization

- in the absence of explicit initialization:

(1) external and static variable are initialized to zero

(2) automatic and register variables have undefined initial value

- in explicit initialization:

(1) for external and static variables:

- the initialier must be a constant expression
- the initialization is done once before the program begins execution

(2) for automatic and static variables:

- initializer may be any expression involving previously define value
- it is done each time the function or block is entered

```
int x=1;
char c='a'+5;
```

```
int binsearch(int x, int v[],int n)
{   int low=0;
    int high=n-1;
    …}
```

4.9 Initialization

The initialization of an array: PROJECT FILE 的应用讲解

- with a list initializes enclosed in braces and separated by commas

  int days[]={31,28,31,30,31,30,31,31,30,31,30,31}

- if there are fewer initializers

(1) for external or static variables: the others will be zero

(2) for automatic variables: the others will be undefined

```
static int a[4]={1,2}; /*a[2],a[3] will be 0 */
```

```
int f()
{   int a[4]={1,2};  /*  a[2],a[3] will be undefined  */
    …
}
```

for character array's initialization: a string can be used

char s[]="hello"; <== > char s[]={'h','e','l','l','o','\0'};

4.10 Recursion

recursion: function call itself either directly or indirectly

Example :

```
#include <stdio.h>
/* printd: print n in decimal */
void printd(int n)
{  if (n<0)  {
          putchar('-');
         n=-n;
    }
    if (n/10) printd(n/10);
    putchar(n%10+'0');
}
```

printd(123)---------→ putchar(3+'0');

↓

printf(12) ----------→putchar(2+'0');

↓

printf(1)----------→ putchar(1+'0');

result: 123

- **函数的递归（recursion）调用**
- ☆ 在调用一个函数的过程中又出现直接或间接地调用该函数本身，称为函数的 **递归调用**。
- ☆ C语言的特点之一就在于允许递归调用。
- int f(int x) /* 直接调用本函数的例子 */
- { int y, z;
- ……
- z = f(y);
- ……
- return(2*z);}
- /* 间接调用本函数的例子 */
- int f1(int x) int f2(int t)
- { {
- int y, z; int a, c;
- ……
- z = f2(y); c = f1(a);
- ……
- return(2*z);} return(3+c);}
- ☆ 应当有能终止递归过程的条件出现，否则就会进入无穷递归。

- 【Example 1】有5个人坐在一起，问第5个人多少岁？他说比第4个人大2岁。第4个人说比第3个人大2岁。第3个人说比第2个人大2岁。第2个人说比第1个人大2岁。第1个人说他10岁。请问第5个人多大？
- 〖分析〗
- 显然，这是一个递归问题：
- age(5) = age(4) + 2
- 回 age(4) = age(3) + 2 递
- age(3) = age(2) + 2
- 推 age(2) = age(1) + 2; 推
- age(1) = 10
- 可表示为**递归公式**：
- 10 n = 1
- age(n) =
- age(n-1)+2 n > 1
- 使递归结束的条件：age(1) = 10;

- 〖Solution〗
- #include <stdio.h>
- int age(int n)
- { int c;
- if (n == 1) c = 10;
- else c = age(n-1) + 2;
- return(c);}

- main()
- { printf("%d", age(5));}

- 〖执行过程示意图〗
- age函数 age函数 age函数 age函数 age函数
- main n=5 n=4 n=3 n=2 n=1
- age(5) c=age(4)+2 c=age(3)+2 c=age(2)+2 c=age(1)+2 c=10
-
- age(5)=18 age(4)=16 age(3)=14 age(2)=12 age(1)=10

【Example 2】用递归方法求n!

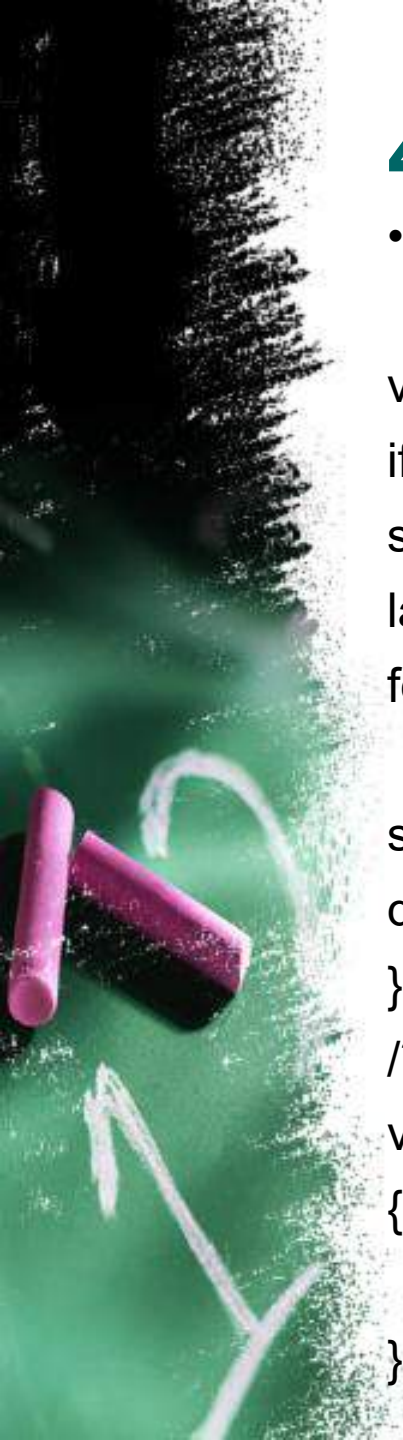
〖递归公式〗

$$n! = \begin{cases} 1 & n = 0,1 \\ (n-1)! \cdot n & n > 1 \end{cases}$$

〖Solution〗

```
#include  <stdio.h>
long fac(int n)
{       long f;
        if (n < 0)                  printf("Error!\n");
        else if (n == 0 || n == 1)
                    f = 1;
             else       f = fac(n-1) * n;
        return(f);}
main()
{       int n;        long y;
        printf("Please input an integer number: ");
        scanf("%d", &n);
        y = fac(n);
        printf("%d! = %ld\n", n, y);
}
```

- 【Example 3】Hanoi塔问题：有三根柱子A,B,C。A柱子上有64个大小不等的并且按照从大到小排列好的盘子。要求把这64个盘子从A柱子移到C柱子，在移动过程中可以借助B柱子，每次只允许移动一个盘，且在移动过程中在三根柱子上都保持大盘在下，小盘在上。要求编程序打印出移动的步骤。
- 〖分析〗将n个盘子从A柱子移到C柱子可以分解成以下三个步骤：
- 1、将A上的n-1个盘子借助C柱子先移到B柱子上；
- 2、把A柱子上剩下的一个盘移到C柱子上。
- 3、将n-1个盘子从B柱子借助A柱子移到C柱子上。
- A B C
- A B C
- B A C
- 〖Solution〗 SEE CHAP2_4



4.10 Recursion

- Example : SEE CHAP2_4

```
 /* qsort: sort v[left]..v[right] into increaseing order */
void qsort(int v[], int i, int j);
if(left>=right) return ;  /*do nothing */
swap(v, left, (left+right)/2); /*move paritition elem to v[0] */
last=left;
for(i=left+1; i<=right; i++)  /* partition */
    if(v[i]<v[left]) swap(v, ++last, i);
swap(v, left, last);
qsort(v, last+1, right);
}
/* swap: interchange v[i] and v[j] */
void swap(int v[], int i, int j)
{  int temp;
  temp=v[i];  v[i]=v[j]; v[j]=temp;
}
```

4.11 The C Preprocessor

- 4.11.1 File inclusion

  #include<filename>

  search filename in the complier's "include" directory

  #include "filename"

  search filename in current directory, then in the complier's "include" directory

4.11 The C Preprocessor

- 4.11.2 Macro Substitution

  form:

  ```
  #define name replacement_text
  ```

  macro without arguments:

  ```
  #define PI 3.14159
  ```

  macro with arguments:

  ```
  #define max(A,B) ((A)>(B) ? (A): (B) )
  ```

  max(2+5,6) <==> ((2+5)>(6) ? (2+5): (6)

  notice:

  ```
  #define square(x)  x*x
  ```

  square(i+j) <==> i+j*i+j

  use “#undefine” to undefine a macro

  ```
  #undefine getchar          /* define in <stdio.h>  */
  int getchar(void)  {…}
  ```

4.11 The C Preprocessor

- #: parameter ➔ string

  #define dprint(expr) printf(#expr “= %g\n”,expr)

  dprint(x/y): < == > printf(“x/y” “ = %g\n”, x/y);

  ##: concatenate the actual argument :

  #define paste(front,back) front ## back

  paste(name,1) === > name1

4.11 The C Preprocessor ZHOUSI

- 4.11.3 Conditional Inclusion

form:

(1) #if constant
block1
#elif constant
block2
#else
blockN
#endif

(2) #ifdef name
block1
#else
block2
#endif

(3)#ifdef name
block1
#else
block2
#endif

example:

```
#if SYSTEM==SYSU
    #define HDR “sysv.h”
#elif SYSTEM == BSD
    #define HDR “bsd.h”
#elif SYSTEM == MSDOS
    #define HDR “msdos.h”
#else
    #define HDR “default.h”
#endif
#include HDR
```

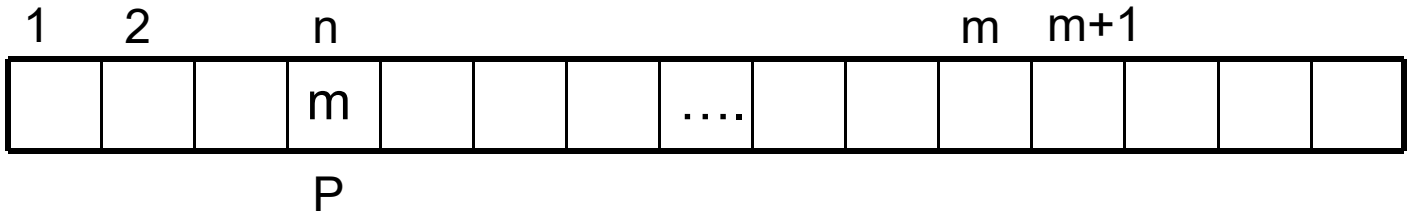
```
#ifdef HDR
  …(block1)
#else
  …(block2)
#endif
```

自编的精彩程序　　现场RUN

```
#include <stdio.h>        discuss      lx   x  sizeof(int *)
main(){
    int x,y,i;
    int a[10];

    printf("\naddress(x)=%x,   address(y)=%x\n",&x,&y);
    printf("address array a=%x\n",a);
    for(i=0;i<10;i++)
          printf("address a[%d]=%x\n",i,&a[i]);}
```

Chapter 5. Pointers and Arrays

5.1 Pointers and Addresses



declare a point:

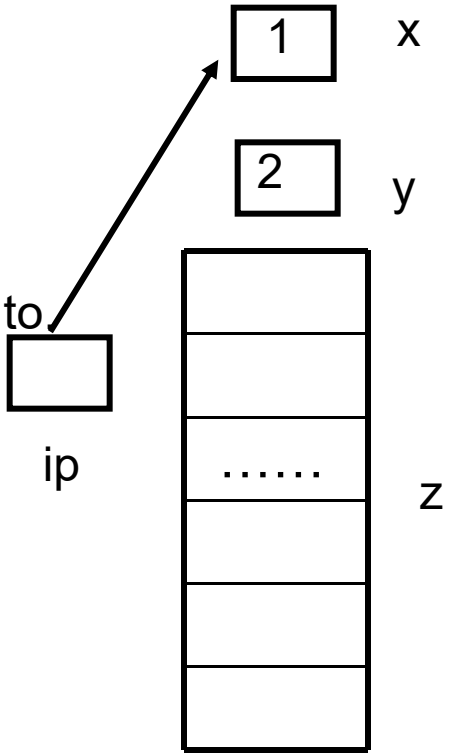
type *namep int *ip;

operate:

(1) &: give the address of an object:

(2) *: access the object the pointer points to

```
int x=1,y=2,z[10];
int *ip;        /*ip is a pointer to int */
ip=&x;          /*ip now points to x */
y=*ip;          /* y is now 1 */
*ip=0;          /* x is now 0 */
ip=&z[0]; /*ip now points to z[0] */
```



5.2 Pointers and Function Arguments

C passes arguments to functions by value

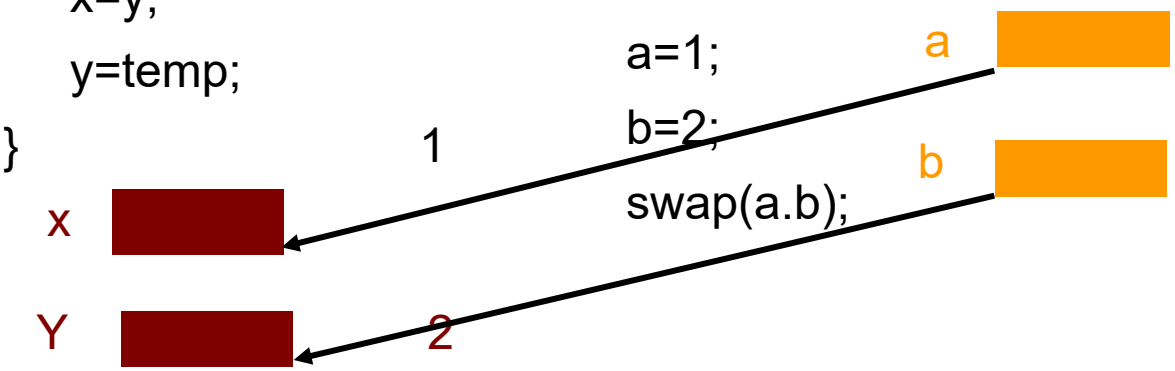
There is no direct way for the called function to alter a variable in the calling function

If we have a function to exchange the values of two integer variables

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

and it is called in main

```
int a, b;
……
a=1;
b=2;
swap(a.b);
```



5.2 Pointers and Function Arguments

Pointer arguments enable a function to

access and change objects

in the function that called it.

An example

Fill an array with integers by calls to getint that performs free-format input conversion by breaking a stream of characters into integer values.

There is a loop in the calling function:

```
int n,array[SIZE], getint(int *);

for(n=0; n< SIZE&& getint(&array[n])!=EOF; n++)
;
```

5.2 Pointers and Function Arguments

```
#include <ctype.h>
int getch(void);
void ungetch(int);
int getint(int *pn)
{           int c, sign;
            while(isspace(c=getch()))   /*skip white space */
            ;
            if(!isdigit© && c!= EOF && c!='+' && c!='-') {
                        ungetch(c);                    /* it's not number */
                        return 0;
}
sign = (c == '-') ? -1:1;
if( c== '+' || c=='-')
c=getch();
for(*pn =0; isdigit( c); c=getch())
*pn=10* *pn +(c-'0');
*pn *=sign;
if(c != EOF)
            ungetch( c);
return c;
}
```

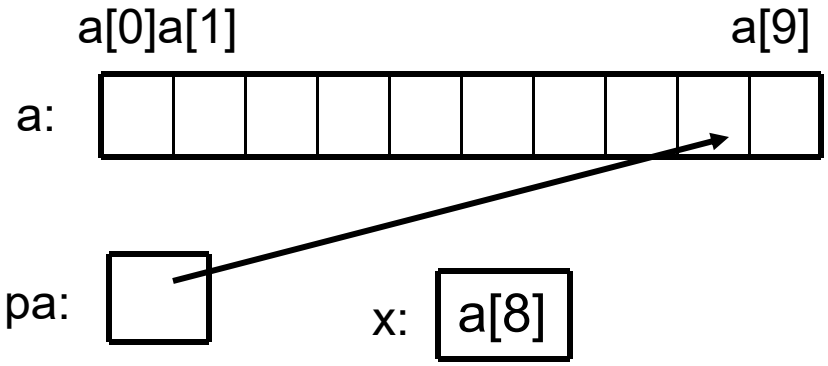
5.3 pointers and Arrays

- There is a strong relationship between pointers and arrays, any operation that can be achieved by array subscripting can also be done with pointers.

5.3 pointers and Arrays

Let's see an example:

```
int  a[10], *px, x;
……
px=&a[0];
x=*pa;
x=*(pa+2);
px=&a[8];
x=*px;
```



which can be done by following program:

```
int a[10], x;
…..
x=a[0];
x=a[2];
x=a[8];
```

5.3 pointers and Arrays

- Since the name of an array is synonym for the location of the initial element, the assignment pa=&a[0] can also be written as

  pa=a;

- Rather more, in evaluating a[i], C converts it to *(a+i) so

  &a[i] < == > a+i

5.3 pointers and Arrays

- Note:

  A pointer is a variable, so pa= a and pa++ are legal but an array name is not a variable, so a=pa and a++ are illegal.

5.3 pointers and Arrays

When an array name is passed to a function, what is passed is the location of the initial element,

```
int stelen(char *s)
{    int n;
     for(n=0;*s!='\0';s++)
              n++;
      return n;
}
```

1: argument s is a local variable, it is a pointer, so s++ is legal.

2: It's a local variable of the function strlen, so s++ only increments strlen's private copy of the pointer.

3: So, in the calling function, the calls like

strlen("hello, world");

strlen(array);

strlen(ptr);

all work.

5.3 pointers and Arrays

- Within strlen, the parameter declaration can be written as

```
int strlen(char *s)
```

or

```
int strlen(char s[])
```

They are equivalent.

We prefer the latter because it says more explicitly that the parameter is a pointer.

5.4 Address Arithmetic

If p is a pointer to some element of an array

1: Pointer adds a number or subtracts a number

```
p++;  /* increments p to point to the next element */
p--;  /* decrements p to point to the previous element */
p +=i;  /* increment it to point i element beyond it points now */
```

2: Subtraction between pointers

```
int strlen(char *s)
{    char *p = s;
     while(*p != '\0')
          p++;
     return  p-s;
}
```

3: Comparison between pointers

If p and q point to members of the same array, then relations like == != < > >=, etc. work properly.

p< q is true if p points an earlier member of the array than q does

5.4 Address Arithmetic

An example about a rudimentary storage allocator. There are two rountines.

.alloc(n) returns a pointer to n consecutive character positions.

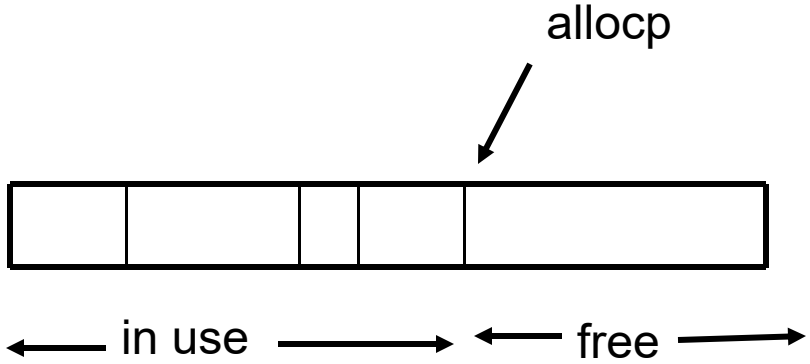
.afree(p) release the storage thus acquired so it can be re_used later.

```
#define ALLOSIZE 10000
static char allocbuf[ALLOCSIZE];
static char *allocp = allocbuf;
char *alloc(int n)
{           if(allocbuf + ALLOSIZE – allocp >= n)
            {   allop += n;
                return allocp – n;
            }
            else return 0;
}
void afree(char *p)
{           if( p >= allocbuf && p < allocbuf + ALLOCSIZE)
                        allocp = p;
}
```

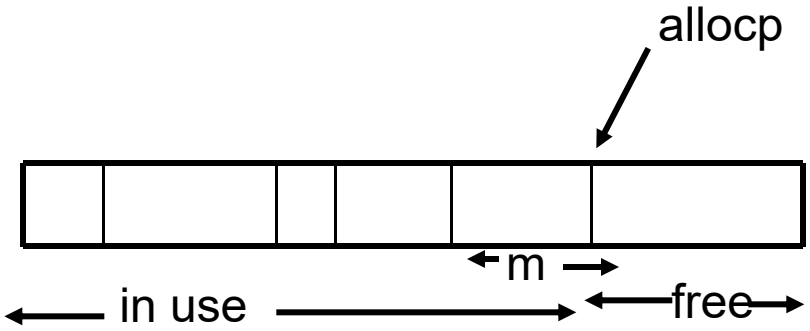
5.4 Address Arithmetic

```
char *p;
    to alloc

int m;

……

p = alloc(m);

……

afree(p);
```

before call



after call to alloc and before call to afree



5.5 Character Pointers and Functions

1: A string constant is accessed by a pointer to its first element.

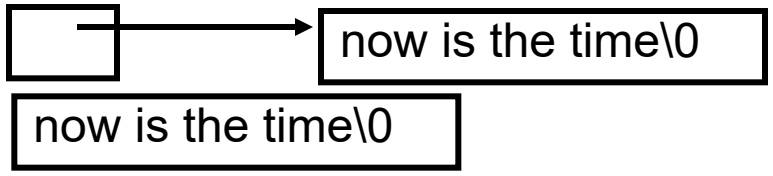
```
printf("hello, world\n");
        /* printf received a pointer which point to "hello, world\n"  */
char *pmessage;
pmessage = "now is the time";
        /*pmessage is assigned by a pointer to the character array
*/
```

2: Diffreence between character array and character pointer.

```
char amessage[] = "now is the time";
char *pmessage = "now is the time";
```

pmessage:

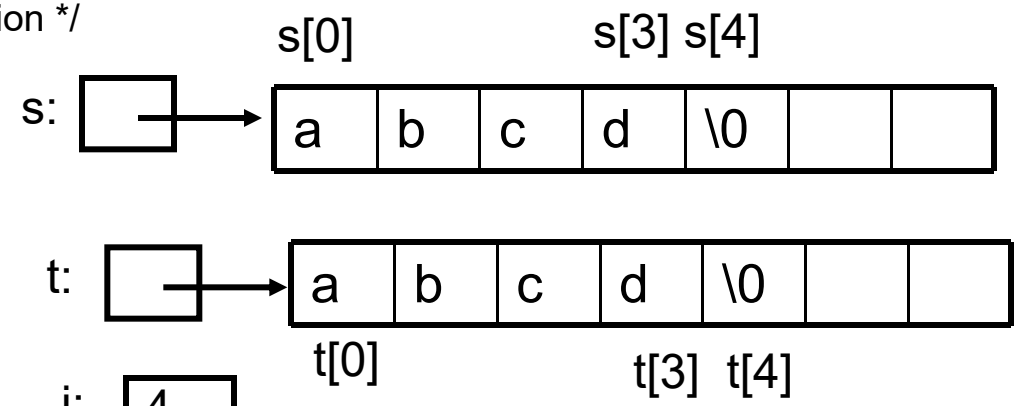
amessage:



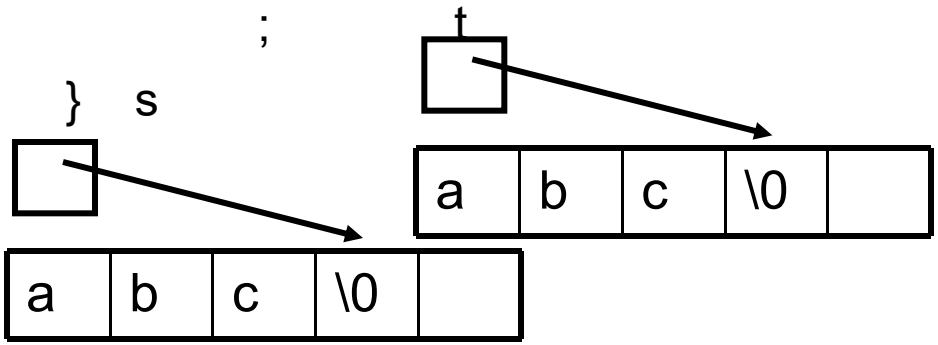
5.5 Character Pointers and Functions

Examples of strcpy:

```
/* strcpy: array subscript version */
void strcpy(char *s, char *t)
{
        int i;
        i=0;
        while((s[i]=t[i]) != '\0')
                i++;
}
/* strcpy: pointer version 1 */
void strcpy(char *s, char *t)
{
        while((*s = *t) != '\0')
        {
                s++; i++;
        }
}
/* strcpy: pointer version 3 */
void  strcpy(char *s, char *t)
{
        while(*s++ = *t++)
                ;
}
```



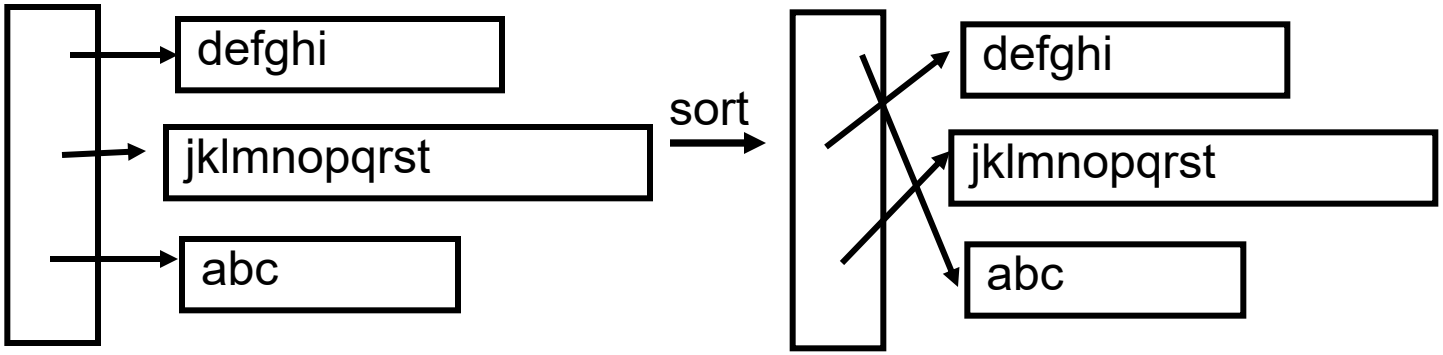

```
/* strcpy: pointer version 2 */
void strcpy(char *s, char *t)
{
        while((*s++=*t++)!='\0')
        ;
}
```



5.6 Pointer Arrays: Pointer to Pointer

Pointer array is an array which stores pointers.

An example to sort a set of text lines into alphabetic order.



Algorithm:

read all the lines of input

sort them

print them in order

5.6 Pointer Arrays: Pointer to Pointer

```
# include<stdio.h>
#include <string.h>
#define MAXLINES 5000
char *lineptr[MAXLINES];
void readlines(char *lineptr[], int nlines);
void writelines(char *lineptr[], int nlines);
void qsort(char *lineptr[], int left, int right);
/* sort input lines */
main()
{    int nlines;        /* number of input lines read */
     if((nlines=readlines(lineptr,MAXLINES))>=0) {
            qsort(lineptr,0,nlines-1);
            writelines(lineptr,nlines);
            return 0;
     }    else {  printf("error: input too big to sort\n");
                     return 1;         }
}
```

5.6 Pointer Arrays: Pointer to Pointer

```
#define MAXLINE 1000              /* max length of any input line */
int getline(char *, int);
char *alloc(int)
/* readlines: read input lines */
int readlines(char *lineptr[],int maxlines)
{       int len, nlines;
        char *p, line[MAXLINE];
        nlines=0;
        while((len = getline(line, MAXLINE)) >0)
                if(nlines >= maxlines || (p=alloc(len)) ==NULL)
                    return -1;
                else {  line[len-1]='\0';  /*delete newline  */
                                strcpy(p, line);
                                lineptr[nlines++]=p;
                        }
        return nlines;
}
void writelines(char *lineptr[], int nlines)
{       int i;
        for ( i=0; i<lines; i++)
                printf("%s\n",lineptr[i]);
}
```

```
while(nlines-- >0)
        printf("%s\n", *nlineptr++);
```

5.6 Pointer Arrays: Pointer to Pointer

```
/* qsort: sort v[left]…v[right] into increasing order */
void qsort(char *v[], int eft, int right)
{     int i, last;
      void swap(char  *v[], int i, int j);
       if(left >= right)  return;
       swap(v, left, (left+right)/2);
       last=left;
       for(i=left+1; i<=right; i++)
                 if(strcmp(v[i],v[left]) <0)
                       swap(v, ++last,i);
        swap(v,left,last);
        qsort(v, left, last-1);
        qsort(v, last+1, right);
}
void swap(char *v[], int i, int j)
{       char *temp;
        temp=v[i];
        v[i]=v[j];
       v[j]=temp;
}
```

5.7 Multi-Dimensional Arrays

chap2_3 3.2 chap2_6 6.3.4

```
/* daytab is a 2-demensional array */
static char daytab[2][13]={
{     {0,31,28,31,30,31,30,31,31,30,31,30,31},
      {0,31,29,31,30,31,30,31,31,30,31,30,31}
};
int day_of_year(int year, int month, int day)
{      int i, leap;
       leap= year%4 ==0 && year%100!= 0|| year%400==0);
       for (i=1;i<month; i++)       day += daytab[leap][i];
       return day;
}
void month_day(int year, int yearday, int *pmonth, int *pday)
{     int i, leap;
      leap = year %4 ==0 && year%100 != 0 || year%400 ==0;
     for(i=1; yearday > daytab[leap][i]; i++)
              yearday -= daytab[eap][i];
     *pmonth = i;
    *pday = yearday;
}
```

5.8 Initialization of Pointer Arrays

```
/* month_name : return name of n-th month */
char *month_name(int n)
{
    static char *name[] = {
            “Illegal month”,
            “january”, “february”, “march”,
            “april”, “may”, “june”, “july”,
            “august”, “september”, “october”,
            “november”, “december”
    };
    return (n< 1 || n>12) ? name[0] : name[n];
}
```

5.9 Pointers vs. Multi-dimensional Array

Difference between a two-dimensional array and an array of pointer:

int a[10][20];

int *b[10];

Although a[3][4] and b[3][4] are both syntactically legal reference to a single int, but:

1: a is a true two-dimensional array, b is only a one-dimensional array

2: a has 200 int-sized locations, b only 10 pointers.

3: the rows of b may be of different lengths.

Because of 3, the most frequent use of arrays of pointers is to store character strings of diverse lengths.

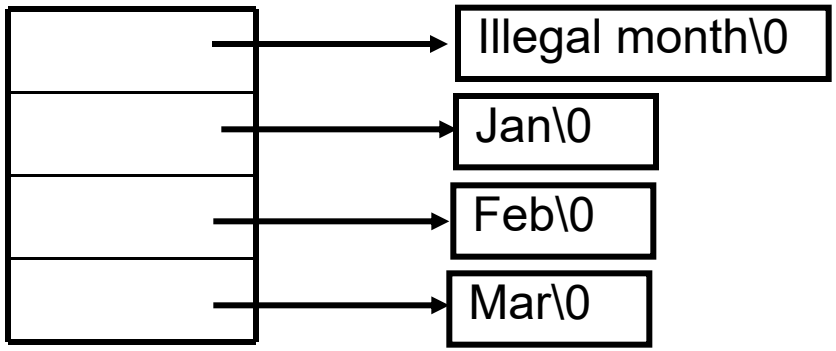
5.9 Pointers vs. Multi-dimensional Array

Example:

char aname[][15] = {“Illegal month”, “Jan”, “Feb”, “Mar”};

aname: | Illegal\0 month\0 Jan\0 Feb\0 Mar\0 |

char *name[]={“Illegal month”, “Jan”, ”Feb”, “Mar”};



5.10 Command-line Arguments

In environments that support C, there is a way to pass command-line arguments or parameters to a program when it begins executing.

Example:

```
/* echo command-line arguments: 1st version*/
main(int argc, char *argv[])
{       int i;
        for(i=1; i< argc; i++)
            printf("%s%s", argv[i], (i<argc-1)? " ":"");
        printf("\n");
        return 0;
}
/*echo command-line arguments: 2nd version*/
main(int argc, char *argv[])
{
        while(--argc >0)
              printf("%s%s", *++argv, (argc>1) ? " " : "");
        printf("\n");
        return 0;
}
```

5.10 Command-line Arguments

example 2:

```
#include <stdio.h>
#include <string.h>
#define MAXLINE 1000
int getline(char *line, int max);
/*find: print lines that match pattern from 1st arg */
main(int argc, char *argv[])
{       char line[MAXLINE];
        int found=0;
        if( argc!=2) printf("Usage: find pattern\n");
        else while (getline(line, MAXLINE)>0)
                if(strstr(line, argv[1])!=NULL) {
                        printf("%s", line);
                        found++;
                }
        return found;
}
```

5.10 Command-line Arguments

example 3:

find –x –n pattern x: execpt, n:print line number

```
#include <stdio.h>

#include <string.h>

#define MAXLINE 1000

/*find: print lines that match pattern from its arg*/
```

5.10 Command-line Arguments

```
main(int argc, char *argv[])
{       char line[MAXLINE];
        long lineno=0;
        int c,execpt=0, number=0, found=0;
        while (--argc>0 && (*++argv)[0] == '-')
                switch(c ) {
                        case 'x': execpt =1; break;
                        case 'n': number=1; break;
                        default:
                             printf("find: illegal option %c\n", c);
                             argc=0; found=-1;break;
                }
         if(argc!=1) printf("Usage: find –x –n pattern \n");
        else…
```

5.10 Command-line Arguments

```
…
while (getline(line, MAXLINE) >0 ) {
    lineno++;
    if(( strstr(line, *argv)!= NULL)!= execpt) {
            if(number) printf(“%ld:”, lineno);
            printf(“%s”, line);
            found++;
    }
 }
 return found;
}
```

5.11 Pointers to Functions

pointers to functions: can be assigned, placed in arrays, passed to functions, returned by functions, …

example:

```
#include <stdio.h>
#include <string.h>
#define MAXLINES 5000  /*max lines to be sorted */
char *lineptr[MAXLINES];  /*pointers to text lines  */
int readlines(char *lineptr[], int nlines);
void qsort(void *lineptr[], int left, int right, int (*comp)(void *, void *));
int numcomp(char *, char *);
/* sort input lines */
```

5.11 Pointers to Functions

```
main(int argc, char *argv[])
    {       int nlines;             /* number of input lines read */
            int numeric =0;     /* 1 if numeric sort  */
            if(argc>1 && strcmp(argv[1], “-n”)==0) numeric =1;
            if((nlines = readlines(lineptr,MAXLINES)) >=0)  {
                    qsort((void **)lineptr, 0, nlines-1,
                            (int (*) (void*, void*))(numeric?numcmp:strcmp));
                    writelines(lineptr,nlines);
                    return 0;
            }else {printf(“input too big to sort\n”);
                            return 1;
            }}
```

5.11 Pointers to Functions

```
/* qsort: sort v[left]…v[right] into increasing order */
void qsort(void *v[], int left, int right, int (*comp)(void *, void *))
{     int i,last;
      void swap(void *v[],int int);
      if(left>=right) return;
      swap(v,left,(left+right)/2);
      last=left;
      for(i=left+1;i<=right;i++)
            if((*comp)(v[i],v[left])<0)   swap(v,++last,i);
      swap(v,left,last);
      qsort(v,left,last-1,comp);
      qsort(v,last+1,right,comp);
}
void swap(void *v[],int i,int j)
{     void *temp;
      temp=v[i];
      v[i]=v[j];
      v[j]=temp;
}
```

int *comp(void *,void *))

```
int numcmp(char *s1, char *s2)
{    double v1,v2;
      v1=atof(s1);
      v2=atof(s2);
      if(v1<v2)   return -1;
      else if (v1>v2)  return 1;
      else return  0;
}
```

5.12 Complicated Declarations

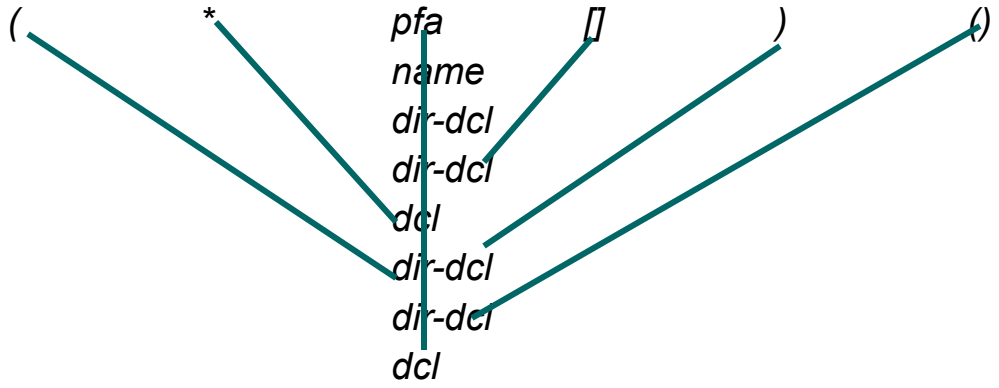
- declarations to word descriptions:
  - *int *f();*
    - f: function returning pointer to int
  - *int (*f)()*
    - f: pointer to function returning int
  - *char **argv*
    - argv: pointer to pointer to char
  - *int (*daytab)[13]*
    - daytab: pointer to array[13] of int
  - *void *comp()*
    - comp: function returning pointer to void
  - *void (*comp)()*
    - comp: pointer to function returning void
  - *char (*(*x())[])()*
    - x: function returning pointer to array[] of pointer to function returning char
  - *char (*(*x[3])())[5]*
    - x: array[3] of pointer to function returning pointer to array[5] of char

5.12 Complicated Declarations

- convert C declaration to a word description:
  - *grammar:*

dcl:	optional *'s	direct-dcl
direct-dcl:	name	
	(dcl)	
	direct-dcl()	
	direct-dcl[optional size]	

  - *example；* *(*pfa[])()*



5.12 Complicated Declarations

programs that convert:

```
/*dcl: parse a declarator */
void dcl(void)
{     int  ns;
      for(ns=0;gettoken()==‘*’;)   ns++; /*count *’s
*/
      dirdcl();
      while(ns-- >0) strcat(out, “pointer to”);
}
/*  dirdcl: parse a direct declaration */
```

5.12 Complicated Declarations

```
void dirdct(void)
{   int   type;
    if( tokentype  ==  ‘(‘)  {
        dcl();
        if(tokentype  != ‘)’)  printf(“error: missing )\n);
    }  else if(tokentype ==NAME) strcpy(name, token);
        else printf(“error: expected name or (dcl)\n”);
   while(( type=gettoken()) ==PARENS || type ==BRACKETS)
        if(type ==PARENS)  strcat(out, “ function returning”);
        else {  strcat(out, “array”);
                 strcat(out, token);
                strcat(out, “ of”);
        }
}
```

5.12 Complicated Declarations

```
#include<stdio.h>

#include <string.h>

#include <ctype.h>

#define MAXTOKEN  100

enum  {NAME, PARENS , BRACKETS  };

void  dcl(void);

void  dirdcl(void);

int gettoken(void);

int tokentype;          /*type of last token */
```

5.12 Complicated Declarations

```
char token[MAXTOKEN];  /* last token string */
char name[MAXTOKEN];   /* identifier name */
char datatype[MAXTOKEN];  /*data type = char, int ,ect. */
char out[1000];    /*output string */
main()   /*convert declaration to words  */
{    while(gettoken()!= EOF)  {          /* 1st token on line */
            strcpy(datatype, token);      /*is the datatype */
            out[0]  = '\0';
            dcl();
            if(tokentype !='\n') printf("syntax error\n");
            printf("%s: %s\n", name, out, datatype);
     }
     return 0;
}
```

5.12 Complicated Declarations

```
int gettoken(void)          /*return next token */
{   int c, getch(void);
    void ungetch(int);
    char *p = token;
    while ((c=getch())  == ' ' || c=='\t');
    if (c=='(')  {
            if(( c = getch()) == ')') {
                strcpy(token,"()");
                return  tokentype = PARENS;
            }   else { ungetch( c);      return tokentype = '('; }
    }
```

5.12 Complicated Declarations

```
else if (c=='[')  {
                for (*p++  =c; (*p++  = getch()) != ']'; );
                *p='\0';
                return tokentype = BRACKETS;
    }  else if(isalpha(c ))  {
                for(*p++  =c; isalnum(c=getch()) ; }
                      *p++ =c;
                *p='\0';
               ungetch(c );
              return tokentype  = NAME;
    }  else return tokentype =c;
}
```

5.12 Complicated Declarations

```
undcl:  x()*[]*()char == > char (*(*x())[])()
      /*undcl: convert word description to declaration */
main()
{     int type;
      char temp[MAXTOKEN];
      while (gettoken()!=EOF) {
            strcpy(out,token);
            while((type= gettoken())!='\n')
                  if((type== PARENS || type == BRACKETS)
                        strcat(out,token);
                  else if(type=='*')  {
                        sprintf(temp, "(*%s)", out);
                        strcpy(out,temp);
                  }  else if (type==NAME)  {
                        sprintf(temp, "%s %s", token, out);
                        strcpy(out, temp);
                  } else printf("invalid input at %s\n", token);
            printf("%s\n", out);
      }
      return 0;
}
```

Chapter 6: Structures

structure: a collection of one or more variables, possible of different type, grouped together under a single name

structures: may be copied, assigned to, passed to functions and returned by functions.

中文结构体的每字含义：

结：set结集，集合

构：构建 STRUCT { }

体：命名STRUCT{} STUDENT

6.1 Basics of Structures

example: ARRAY AND STRUCT下页
COMPARISION

```
struct pointer {
        int  x;
        int  y;
};
```

define…;

```
struct pointer {
        int x;
        int y;
}p1,p2 p3;
```

```
struct pointer {
        int x;
        int y;
};
struct pointer p1,p2,p3;
```

```
struct {
        int x;
        int y;
} p1,p2,p3;
```

- Int a[10];　　a[0] a[1] a[2].....a[9]
- Struct array_a{ int a0;
- 　　int a1;　/*可以是任何类型*/
- 　　int a2;
- 　　.....
- 　　int a9;
- 　　} a;
- 　　访问元素：数组　a[i]; 结构体　a.ai

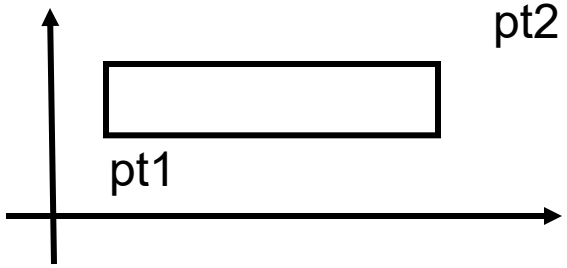
6.1 Basics of Structures

member refering: structure-name.member

```
    struct pointer pt;
        printf("%d,%d", pt.x, pt.y);
        double dist, sqrt(double);
        dist = sqrt((double)pt.x * pt.x+ (double)pt.y * pt.y);
```

structures can be nested

```
    struct rect {
        struct point pt1;
        struct point pt2;
    };
struct rect screen;
screen.pt1.x
```



6.2 Structures and Functions

operations on structure:

assigning, taking address &, accessing members

CAN NOT: compared

examples: manipulate points an rectangles

```
/* makepoint: make a point from x and y components */
struct point makepoint(int x, int y)
{ struct point temp;
    temp.x=x;
    temp.y=y;
    return temp;
}
```

6.2 Structures and Functions

makepoint can be used as:

```
struct rect screen;
struct point middle;
struct point makepoint(int, int);
screen.pt1=makepoint(0,0);
screen.pt2=makepoint(XMAX,YMAX);
middle=makepoint((screen.pt1.x+screen.pt2.x)/2,
                 (screen.pt1.y+screen.pt2.y)/2);
```

6.2 Structures and Functions

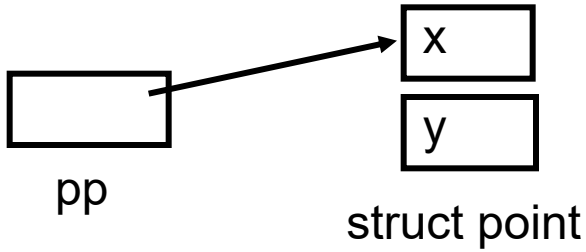
```
/* addpoint: add two points */

struct point addpoint(structure point p1, struct
    point p2)

{   p1.x+=p2.x;

    p1.y+=p2.y;

    return p1;

}

/*ptinrect: return 1 if p in r, o if not */

int ptinrect(struct point p,struct rect r)

{   return p.x >= r.pt1.x && p.x <r.pt2.x && p.y >=
    r.pt1.y && p.y< r.pt2.y;

}
```

6.2 Structures and Functions

```
#define min(a,b) ((a)<(b)? (a) : (b))
#define max(a,b) ((a)>(b)? (a) : (b))
struct rect canorect(struct rect r)
{    struct rect temp;
     temp.pt1.x=min(r.pt1.x, r.pt2.x);
      temp.pt1.y=min(r.pt1.y, r.pt2.y);
     temp.pt1.x=max(r.pt1.x, r.pt2.x);
     temp.pt1.y=max(r.pt1.y, r.pt2.y);
     return temp;
}
```

6.2 Structures and Functions

struct pointer:



struct point *pp;

(*pp).x and (*pp).y
pp->x and pp->y

are members

e.g: struct point origin, *pp;

pp = &origin;

printf("origin is (%d, %d)\n", (*pp).x, (*pp).y);

printf("origin is (%d, %d)\n", pp->x, pp->y);

Notice: . and -> associate from left to right:

struct rect r. *rp=r;

r.pt1.x < == >rp->pt1.x< ==> (r.pt1).x< == > (rp->pt1).x

6.2 Structures and Functions

. , ->,(): at the top of the precedence

If:

```
struct {
        int len;
        char *str;
} *p;
```

Then:

++p->len < == > ++(p->len) different from (++p)->len

*p->str: fetches hatever str points to.

*p->str++: increments str after accessing what it points to (as *s++)

(*p->str)++: increments whatever str points to

*p++ -> str: increments p after accessing whatever str points to

6.3 Arrays of Structures

Example: count the occurences of each C keyword

```
    struct key {
            char *word;
            int count;
    } keytab[]={“auto”, 0, “break”, 0, “case”, 0, …,”while”,0};
#include <stdio.h>
#include <ctype.h>
#include <string.h>
#define MAXWORD 100
int getword(char *, int);
int binsearch(char *, struct key *, int);
```

6.3 Arrays of Structures

```
#define NKEYS (sizeof keytab/sizeof(struct key))

main()
{   int n;
    char word[MAXWORD};
    while (getword(word, MAXWORD)!= EOF)
        if( isalpha(word[0]))
            if(( n =binsearch(word, keytab, NKEYS)) >=0)
                keytab[n].count++;
    for(n=0;n<NKEYS;n++)
        if( keytab[n].count>0) printf("%4d %s\n",
    keytab[n].count,keytab[n].word);
    return 0;
}
```

6.3 Arrays of Structures

```
/* binsearch: find word in tab[0]…tab[n-1] */
int binsearch(char *word, struct key tab[], int n)
{   int cond, low, high,mid;
    low=0;
    while(low<=high) {
        mid=(low+high)/2;
        if ((cond=strcmp(word, tab[mid].word))<0)
            high = mid-1;
        else if (cond >0) low = mid +1;
        else return mid;
    }
return -1;
}
```

6.3 Arrays of Structures

```
/* getword: get next word or character from input */
int getword(char *word, int lim)
{    int c, getch(void);
     void ungetch(int);
     char *w=word;
     while (isspace(c=getch()));
     if(c!=EOF) *w++ =c;
     if(!isalpha(c )) {
          *w =‘\0’;
          return c;
     }
```

6.3 Arrays of Structures

```
for (; --lim>0; w++)
        if(!isalnum(*w=getch())){
            ungtech(*w);
            break;
        }
    *w='\0';
    return word[0];
}
```

6.4 Pointers to Structures

consider the keyword-counting again:

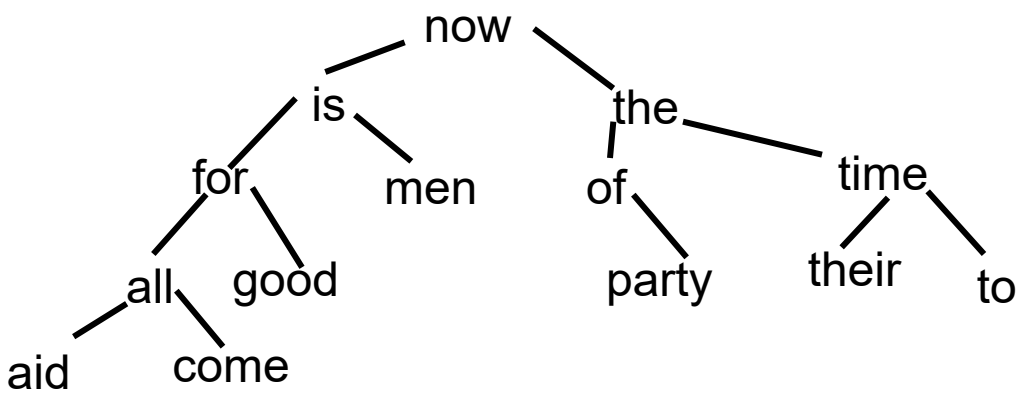
```
#include <stdio.h>
#include <ctype.h>
#include <string.h>
# define MAXWORD 100
int getword(char *, int);
struct key *binsearch(char *, struct key *, int);
main()
{       struct key *p;
        char word[MAXWORD];
        while (getword(word, MAXWORD)!=EOF)
                if(isalpha(word[0]))
                    if((n=binsearch(word, keytab, NKEYS)) >=0)
                            p->count++;
        for( p=keytab; p<keytab+NKEYS; P++)
             if(p->count>0) printf("%4d %s\n", p->count, p->word);
        return 0;
}
```

6.4 Pointers to Structures

```
/* binsearch: find word in tab[0].tab[n-1] */
struct key *binsearch(char *word, struct key tab[], int n)
{    int cond;
     struct key *low=&tab[0];
     struct key *high=&tab[n];
     struct key *mid;
     while (low <=high) {
          mid =low+(high-low)/2;
          if((cond=strcmp(word, mid->word)) <0)
               high= mid-1;
          else if (cond>0) low =mid+1;
          else return mid;
     }
     return NULL;
}
```

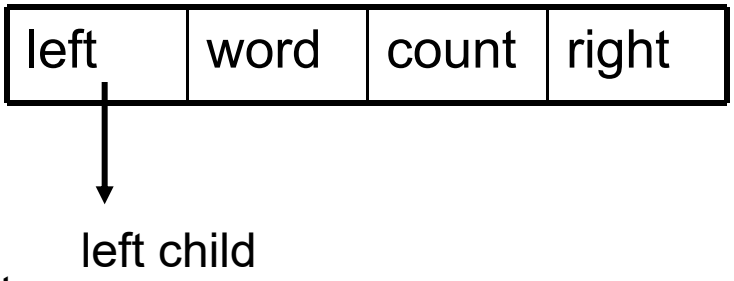
6.5 Self-referential Structures

tree:



describ a node：

```
struct tnode {
        char *word;
        int count;
        struct tnode *left;
        struct tnode *right;
}
```



6.5 Self-referential Structures

example: words counting

```
#include <stdio.h>
#include <ctype.h>
#include <string.h>
#define MAXWORD 100
struct tnode *addtree(struct tnode *, char *);
void treeprint(struct tnode *);
int getword(char *, int);
/* word frequency count */
main()
{    struct tnode *root;
     char word[MAXWORD];
     root=NULL:
     while(getword(word, MAXWORD)!=EOF)
          if(isalpha(word[0])) root=addtree(root,word);
     treeprint(root);
     return 0;
}
```

6.5 Self-referential Structures

```
struct tnode *talloc(void);
char *strdup(char *);
/* addtree: add a node with w, at or below p */
struct tnode *addtree(struct tnode *p, char *w)
{     int cond;
      if(p==NULL){ /*a new word has arrived */
         p=talloc();  /*make a new node */
         p->word = strdup(w);
         p->count =1;
         p->left= p->right=NULL:
      }  else if((cond=strcmp(w, p->word)))==0)
                  p->count++;              /* repeated word */
      else if(cond<0) /*less than left subtree */
                  p->left = addtree(p->left,w);
      else p->right = addtree(p->right,w);
      return p;
}
```

6.5 Self-referential Structures

```
/* treeprint: in-order print of tree p */
void treeprint(struct tnode *p)
{  if(p!=NULL) {
    treeprint(p->left);
    printf("%4d %s\n", p->count, p->word);
    treeprintf(p->right);
}
```

6.5 Self-referential Structures

```
#include <stdlib.h>
/* talloc: make a tnode */
struct tnode *talloc(void)
{    return (struct tnode *) malloc(sizeof(struct tnode));
}
char *strdup(char *s)  /*make a duplicate of s */
{  char *p;
     p= (char *) malloc(strlen(s)+1);  /* +1 for '\0' */
     if(p!=NULL) strcpy(p,s);
     return p;
}
```

6.6 Table Lookup

symbol table management:

install(s,t)

lookup(s)

algorithm:

hash(哈希，杂凑）search: convert name into a small number which used to index into an array of pointers (to list of names)

```
struct nlist {
        struct nlist *next;
        char name;
        char *defn;
}
```

```
#define HASHSIZE 101
static struct nlist *hashtab[HASHSIZE]; /*pointer table */
```

6.6 Table Lookup

```
/* hash: from hash value for string s */
unsigned hash(char *s)
{    unsigned hashval;
     for(hasjval=0; *s!='\0'; s++)
          hashval = *s + 31*hashval;
     return hashval % HASHSIZE;
}
/* lookup: look for s in hashtab */
struct nlist *lookup(char *s)
{ struct nlist *np;
     for( np=hashtab[hash(s)];  n!=NULL; np=np->next)
          if( strcmp(s, np->name)==0)
                    return np;  /*found*/
     return NULL;    /*not found*/
}
```

6.6 Table Lookup

```
struct nlist *lookup(char *);
char *strdup(char *);
/* install: put(name,defn) in hashtab */
struct nlist *install(char *name, char *defn)
{     struct nlist *np;
      unsigned hashval;
      if((np=lookup(name))==NULL { /*not found */
            np= {struct nlist *)malloc(sizeof(*np));
            if(np==NULL|| (np->name = strdup(name)) ==NULL) return NULL;
      hashval = hash(name);
      n[->next = hashtab[hashval];
      hashtab[hashval]=np;   /*insert the new node */
      } else /* already there */
            free((void *) np->defn);  /* free previous defn */
      if((np-> defn = strdup(defn)) ==NULL ) return NULL;
      return np;
}
```

6.7 Typedef

typedef: creating new data type name (not a new type)

purpose: (1) for portable (2) for better understanding

example:

```
char *s;
int strcmp(char *, char *);
```

```
typedef char *STRING;
STRING s;
int strcmp(STRING,STRING);
```

```
int (*strcmpp)(char *, char *);
```

```
typedfe int (*PFI)(char *,char *);
PFI strcmpp;
```

```
struct tnode{
      char *word;
      int count;
     struct tnode *left;
     struct tnode *right;
};
struct tnode *tp;
struct tnode node;
```

```
typedef struct tnode *TREEPTR;
typedef struct tnode {
                char *word;
                int count;
                TREEPTR left;
                TREEPTR right;
}  TREENODE;
TREEPTR tp;
TREENODE node;
```

6.8 Unions

union: manipulate different kinds of data in a single area of storage

example:

```
union u_tag {
        int ival;
        float fval;
        char cval;
} u;
```

Notice: any one of these types may be assigned to u and then used in expressions, so long as the usage is consistent: the type retrieved must be the type most recently stored.

access members:

union-name.member

union-pointer->member

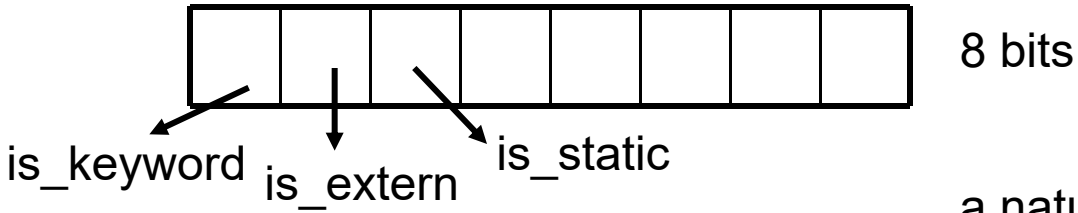
union is a structure in which all members have offset zero form the base.

union may only be initialized with a value of the type of its first member.

6.9 Bit-fields(位段)

compiler symbol tables, interfaces to hardware devices often require the ability to get at pieces.

flag of symbol table:



a usual way:

```
#define KEYWORD 01
#define EXTERNAL 02
#define STATIC 04
flag2|= EXTERNAL|STATIC
flags&=~(EXTERNAL|STATIC);
```

a natural way:

```
struct {
    unsigned int is_keyword : 1;
    unsigned int is_extern : 1;
    unsigned int is_static : 1;
}flags;
flags.is_extern = flag.is_static =1
flags.is_extern = flags.is_static=0;
```

Notice: .fields may be declared only as ints + signed/unsigned .fields are not arrays, not have address (thus & can not be applied)

Chapter 7. Input and Output

Input and Output are not part of C language, but provided by standard library, including a set of functions.

7.1 Standard Input and Output

character input and output:

int getchar(void) /* read a character from the standard input */

int putchar(int) /* put a character on the standard output */

Notion:

1 input and output can be redirected. such as

prog < infile

prog > outfile

prog | anotherprog

2 Each source file that refers to an input/output library must contain the line

#include <stdio.h>

7.1 Standard Input and Output

An example: converts input to lower case

```
#include <stdio.h>
#include <ctype.h>
main()  /* lower: convert input to lower case */
{    int c;
     while(( c= getchar())!=EOF)
               putchar(tolower(c));
     return 0;
}
```

7.2 Formatted Output-Printf

int printf(char *format, arg1, arg2, …)

Notion:

- The printf converts, formats and prints its arguments on the standard output under the control of the format.
- It returns the number of characters printed.
- The format string contains two types of objects: ordinary characters, which are copied to the output stream, and conversion specification, each of which causes conversion and printing of the next successive argument to printf.

7.2 Formatted Output-Printf

Conversion specfications: (int i=55; char s[]="hello, world";)

1 printf("%d", i); :55

2 printf("%5d", i); : 55

3 printf("%-5d", i); :55

4 printf(f, s); f are the following cases:

%s :hello, world;

%10s :hello, world;

%.10s :hello, wor;

%-10s :hello,world;

%.15s :hello, world;

%-15s :hello, world ;

%15.10s : hello, wor;

%-15.10s :hello, wor ;

5 printf("%%d");

7.2 Formatted Output-Printf

int sprintf(char *string, char *format, arg1, arg2,…)

The function does the same conversion as printf does, but stores the output in a string.

eg: char s[100];

int a=1, b=2;

sprintf(s, “%d + %d = %d”, a, b);

The content of s is “1 + 2 = 3”

7.3 Variable-length Argument Lists

The proper declaration for printf is

int printf(char *fmt, …)

where the … means that the number and types of these arguments may vary. The … can only appear at the end of an argument list.

minprintf is a simple version of printf

```
#include <stdarg.h>

void minprintf(char *fmt, …)
{       va_list ap;
        char *p, *sval;
        int ival;
        double dval;
```

7.3 Variable-length Argument Lists

```
va_start(ap, fmt);
for(p=fmt; *p; p++)  {
        if(*p!='%') {
                putchar(*p);
                continue;
        }
        switch(*++p)  {
                case 'd': ival = va_arg(ap,int);
                        printf("%d", ival);
                        break;
                case 'f' : dval=va_arg(ap,double);
                        printf("%f", dval);
                        break;
```

7.3 Variable-length Argument Lists

```
case ‘s’ : for(sval = va_arg(ap,char *); *sval; sval++)
                                        putchar(*sval);
                                        break;
                        default: putchar(*p);
                                        break;
                        }
                }
                va_end(ap);
        }
```

7.4 Formatted Input-Scanf

int scanf(char *format, …)

int sscanf(char *string, char *format, arg1, arg2, …);

1 scanf reads characters from the standard input, interprets them according to the specification in format.

2 sscanf is like scanf does, but from string, not from standard input

3 the format strng is just like printf, only for ordinary characters (not %), which are expected to match the next non-white space character of the input stream.

eg1: int day, year;

char monthname[20];

scanf(“%d %s %d”, &day, &monthname, &year);

eg2: int a, b, c;

char s[]= “3 4 5 6 7”;

sscanf(s, “%d %*d %*d %d %d”, &a, &b, &c);

The result is a==3 b==6 and c==7

SEE OLD 13-14

7.5 File Access

SEE OLD VERSION

The general steps for a file operation:

1 Open the file

2 Do operations on the file by file pointer.

3 Close a file

In C language, files are accessed by file pointers, which are declared as:

FILE *fp;

During the first step, we can use a fopen to make fp points to the file we want to access.

```
fp = fopen(“data”, “r”);
```

or

```
if((fp=fopen(“data”,”r”)) !=NULL)
```

7.5 File Access

FILE *fopen(char *filename, char *mode);

int fclose(FILE *fp);

1 The filename can include full path, just like:

fp = fopen(“c:\\system\\t.dat”,”r”);

2 The mode can be

“r”: read only

“w”: write only

“a”: append only

If the system distinguish between text and binary files, for the latter, a “b” must be appended to the mode string.

fp = fopen(“t.dat”,”rb”);

3 When operations finished, the file should be closed.

fclose(fp);

7.5 File Access

Functions used to access a file:

1 Read data from a file:

int getc(FILE *fp);

int fscanf(FILE *fp, char *format, …);

int fgets(char *string, int n, FILE *fp);

int fread(char buffer, int size, int count, FILE *fp);

2 Write data int a file:

int putc(int c, FILE *fp);

int fprintf(FILE *fp, char *format, …);

int fputs(char *string, int n, FILE *fo);

int fwrite(char *buffer, int size, int count, FILE *fp)

3 file locate

fseek(FILE *fp, long off, int start);

7.5 File Access

eg1: file copy

```
#include <stdio.h>
main(int argc, char *argv[])
{       FILE *fp1, *fp2;
        if(argc!=3)
        {               printf("Usage: copy f1 f2\n");
                        exit(1);
        }
        if((fp1=fopen(argv[1])) == NULL || ((fp2 = fopen(argv[2]))=NULL)
        {               printf("Can't open file!\n");
                        exit(2);
        }
        while(putc(getc(fp1),fp2)!=EOF)
                        ;
        fclose(fp1);
        fclose(fp2);
}
```

7.5 File Access

eg2: read from a character file, change lower to upper.

```
#include <stdio.h>
main(int argc, char *argv[])
{       FILE *fp1, *fp2;
        char c;
        if(argc!=3)
                exit(1);
        if((fp1==fopen(*++argv,”r”))==NULL || ((fp2=fopen(*++argv,”w”)= NULL)
                exit(2);
        while((c=fgetc(fp1)) !=EOF)
                fputc(c+’A’-’a’,fp2);
        fclose(fp1);
        fclose(fp2);
}
```

7.5 File Access

eg2: concatenate files

```
#include <stdio.h>
main(int argc, char *argv[])
{    FILE *fp;
     if(argc==1)
          filecopy(stdin,stdout);
     else
          while(--argc>0)
               if((fp=fopen(*++argv,"r")) == NULL) {
                    printf("cat:can't open %s\n",*argv);
                    return 1;
               } else {
                    filecopy(fp,stdout);
                    fclose(fp);
               }
          return 0;
}
```

7.5 File Access

```
void filecopy(FILE *ifp, FILE *ofp)
{  int  c;
   while((c=getc(ifp))!=EOF)
    putc(c,ofp);
}
```

7.6 Line Input and Output

char *fgets(char *line, int maxline, FILE *fp)

fgets read next input line (including the newline) from file fp into character array line, at most maxline-1 characters will be read

The result line is terminated with ‘\0’;

int fputs(char *line, FILE *fp)

fputs writes a string to a file(need not contain a newline)

7.6 Line Input and Output

```
char *fgets(char *s, int n, FILE *iop)
{    register int c;
     register char *cs;
     cs=s;
     while(--n >0 && (c=getc(iop))!= EOF)
          if((*cs++ =c)==‘\n’)
               break;
          *cs=‘\0’;
          return (c==EOF && CS ++ S)? NULL : s;
}
int fputs(char *s, FILE *iop)
{    int c;
     while( c =*s++)
          putc(c,iop);
     return ferror(ip) ? EOF : 0;
}
```

Some examples

1、putchar函数可以向终端输出一个_____。

A) 整型变量表达式值

B) 实型变量值

C) 字符串

D) 字符或字符型变量值

1、putch

A) 整型变

C) 字符串

Key: D)

2、以下程序的输出结果是_____。

```
main()
{
      printf("\n*s1=%15s*", "chinabeijing");
      printf("\n*s2=%-5s*", "chi");
}
```

A) *s1=chinabeijing * B) *s1=chinabeijing *
   *s2=**chi*   *s2=chi *

C) *s1=* chinabeijing* D)*s1= chinabeijing*
   s2=chi   *s2=chi *

2、以下程

```
ma
{


}
```

A) *s1=c
s2=

C) *s1=*
*s2=c

Key: D)

3、以下程

```
main()
{
    lo
    pr
    pr
    pr
}
```

A) y=5ba0

y=

y= 0

3、以下程

```
main()
{
    lo
    pr
    pr
    pr
}
```

A) y=5ba0

y=

y= 0

Key: A)

4、若x，y

A) sca

B) scan

C) scan

D) scan

4、若x，y

A) sca

B) scan

C) scan

D) scan

Key: D)

5、阅读以

结果为

```
main()
{
        in
        sc
       pr
}
```

A) x+y+z=

B) x+y+z

C) x+z=3

D) 不确定

5、阅读以

结果为

```
main()
{
        in
        sc
       pr
}
```

A) x+y+z=

B) x+y+z

C) x+z=3

D) 不确定

Key: D)

6、已有定

若从笼

y的值为

【1】A)

【2】A)

6、已有定

若从笔

y的值为

【1】A)

【2】A)

Key: 【1】 B)

【2】 B)

7、以下说

A) 输入

B) 只有格

b=%d"

C) 当输入

scan

D) 当输入

7、以下

A) 输入

B) 只有

b=%d"

C) 当输入

scan

D) 当输入

Key: D)

7、以下

A) 输入

B) 只有

b=%d"

C) 当输入

scan

D) 当输入

Key: D)