Chapter 9
Strings

Problem Solving and Program Design in C

by Jeri R. Hanly and Elliot B. Koffman

Pei-yih Ting @NTU

Outline

- String Basics
- Library Functions: Assignment and Substrings
- Longer Strings: Concatenation and Whole-Line Input
- String Comparison
- Arrays of Pointers
- Character Operations
- String – Integer Conversion
- Case Study: Text Editor
- Common Programming Errors

Introduction

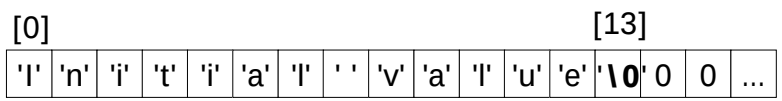
- Typical usages of computers
  - Processing numerical data & **textural** data.
  - Typewriter → word processing systems → preprint system
- Strings:
  - A data structure deals with a group of characters
  - In C: null ('\0') terminated array of characters
- Storage of strings:
  - arrays of type char, e.g. char message[100];
- Example: string constants used till now

```
printf("Hello World!\n");
#define ERR_Message "Error!!"
```


Defining & Initializing Strings

- Since string is an array, the declaration of a string is the same as declaring a char array.

```
char buffer[30];
char message[20] = "Initial value";
```




```
char message[] = {'I', 'n', 'i', 't', 'i', 'a', 'l', ' ', 'v', 'a', 'l', 'u',
                  'e', '\0'};
```

- A string is always ended with a null character '\0' for compatibility with library functions.
- Characters after the null character are ignored by all predefined string processing functions.

Example Application

- Asking the user for an input file name

```
char filename[30];
FILE *fp;
...
printf("Please specify the input file name:");
scanf("%s", filename);

fp = fopen(filename, "r");
if (fp == 0) {
    printf("Error in opening the file %s!!", filename);
    exit(1);
}
```


Arrays of Strings

- An array of strings is defined as an array in which each element is an array of characters (i.e. a two-dimensional array of characters).
- For example
  - #define NUM_PEOPLE 30
  - #define NAME_LEN 25
  - char names [NUM_PEOPLE][NAME_LEN];

  - char months[12][10] = { "January", "February", "March", "April", "May", "June", "July", "August", "September", "October", "November", "December" };

String Output with printf

- The placeholder **%s** indicates string arguments in printf and scanf.

```
printf("Topic: %s\n", title_str);
```

- The formatted string output is right-justified by specifying a positive number in the placeholder.

```
printf("%8s", str);
```

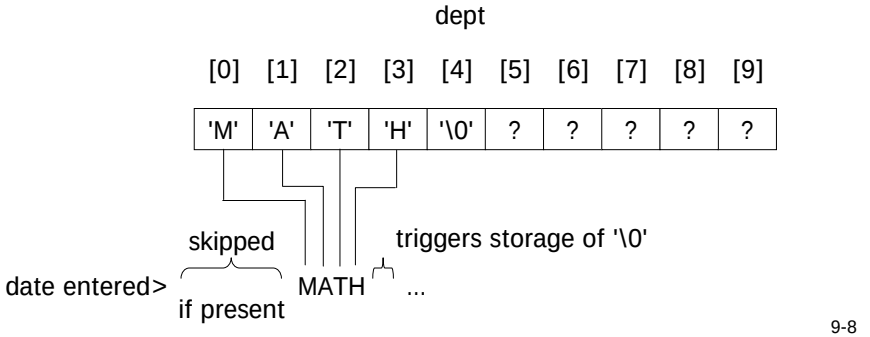
- The formatted string output is left-justified by specifying a negative number in the placeholder.

```
printf("%-8s", str);
```

- If the actual string is longer than the width, the displayed field is expanded with no padding.

String Input with scanf

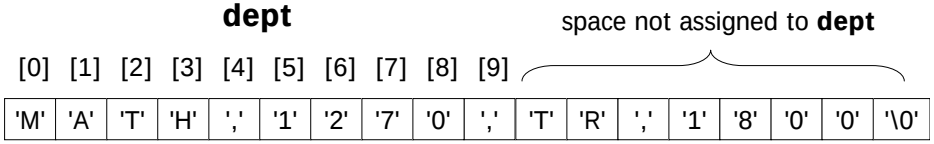
- char dept[10]; scanf("%s", dept); **no & necessary**
- e.g., if the user types "MATH 1234 TR 1800," the string "MATH" along with '\0' is stored into dept.
- Whenever encountering a **white space**, the scanning stops and scanf places the null character at the end of the string.



Entry of Invalid Data

```
char dept[10];
scanf("%s%d%s%d", dept, &course_num,
                  days, &time);
```

- MATH,1270,TR,1800



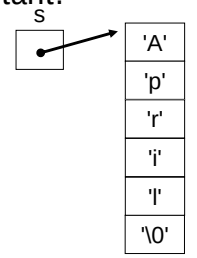
- Correction
  - MATH 1270 TR 1800

String Library Functions

- The string **cannot** be copied by the assignment operator
  str **=** "Test String"; --- incorrect
- Initialization is OK
  char str[] **=** "Test String";
- String manipulating library "string.h" (Appendix B)
- Array identifier is a constant pointer. A string constant is treated like a constant pointer to char constant.

```
void fun(char *s)
{
   ...
}
```

calling the function `fun("April");`



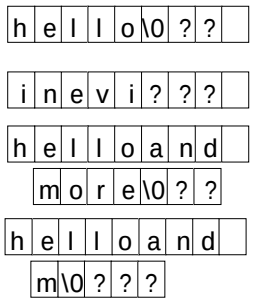
or

```
void fun(char s[]) { ... }
```


String Library Functions

string.h

Function	Purpose	Parameters
strcpy	strcpy(s1, "hello");	char *dest const char *source
strncpy	strncpy(s2, "inevitable", 5); does not add '\0' to s2	char *dest const char *source size_t n
strcat	strcat(s1, "and more");	char *dest const char *source
strncat	strncat(s1, "and more", 5); adding '\0' if necessary	char *dest const char *source size_t n

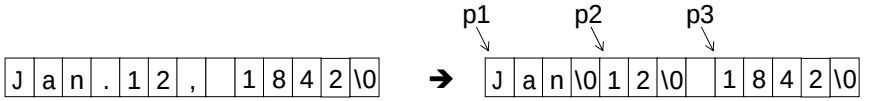


return types are all char* for the usage like
printf("%s", strcat(s1, "and more"));

String Library (cont'd)

Function	Purpose	Parameters	Return type
strcmp	if (strcmp(n1, n2) > 0) string n1 is larger than n2	const char *s1 const char *s2	int
strncmp	if (strncmp(n1, n2, 12) == 0)	const char *s1 const char *s2	int
strlen	strlen("What") returns 4	const char *s	size_t

strtok	let s1 be "Jan.12, 1842"
	p1 = strtok(s1, ".,");
	p2 = strtok(NULL, ".,");
	p3 = strtok(NULL, ".,");
		const char *source
		const char *delim
			char *



String Assignment strcpy

- Function **strcpy** copies the string in the second argument into the first argument.

```
char one_str[20];
strcpy(one_str, "test string");
```

The **null character** is appended at the end automatically.

- If source string is longer than the destination string, the overflow characters may occupy the memory space used by other variables.
- BAD: The values of these other variables change spontaneously and unexpectedly. On rare occasions, such overflow would generate a run-time error message.

```
strcpy(one_str, "A very long test string");
```


strcpy vs. strncpy

- Function **strncpy** copies the string by specifying the number of characters to copy – safer than **strcpy**.
- If source string is longer than the destination string, the overflow characters are discarded automatically.

```
strncpy(dest, source, dest_len-1);
dest[dest_len-1] = '\0'; // = 0 is the same
// must place the null char. manually.
```


Substring Manipulation

- Frequently need to reference a **substring** of a longer character string.
- Use strncpy to copy a middle or an ending portion of a string.

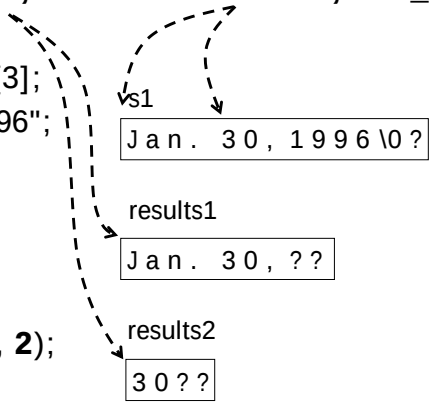
char *strncpy(char *dest, const char *source, size_t n)

- Example:

```
char results1[10], results2[3];
char s1[14] = "Jan. 30, 1996";

strncpy(results1, s1, 9);
results1[9]= '\0';

strncpy(results2, &s1[5], 2);
results2[2]= '\0';
```



Separate Compounds into Components

- assuming that each element name begins with a capital letter and the first character is a capital letter

Figure 9.7

```
01 #include <stdio.h>
02 #include <string.h>
03 #define CMP_LEN  30  /* size of string to hold a compound  */
04 #define ELEM_LEN 10  /* size of string to hold a component */
05 int main(void)
06 {                                  /* string representing a compound */
07     char compound[CMP_LEN];
08     char elem[ELEM_LEN];     /* one elemental component        */
09     int  first, next;
10
11     /*  Gets data string representing compound                 */
12     printf("Enter a compound> ");
13     scanf("%s", compound);
14
15     /*  Displays each elemental component.  These are identified
16        by an initial capital letter.                          */
17     first = 0;
```

Separate Compounds (cont'd)

```
18     for  (next = 1;  next < strlen(compound);  ++next)
19         if (compound[next] >= 'A'  &&  compound[next] <= 'Z') {
20             strncpy(elem, &compound[first], next - first);
21             elem[next - first] = '\0';
22             printf("%s\n", elem);
23             first = next;
24         }
25
26     /*  Displays the last component                          */
27     printf("%s\n", strcpy(elem, &compound[first]));
28
29     return (0);
30 }
```

```
Enter a compound> H2SO4
H2
S
O4
```


String Length

- When writing a string-manipulating program, one usually does not know in advance the sizes of the strings used as data.
- Function **strlen** is often used to calculate the length of a string (i.e., the number of characters before the first null character).

```
char dest[10] = "Hello";
strncat(dest, " more",
                sizeof(dest)-1-strlen(dest));
dest[sizeof(dest)-1] = '\0';
```

- **empty string -** a string of length zero

String Concatenation

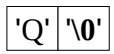
- Functions **strcat** and **strncat** concatenate the first string argument with the second string argument, **strncat** adds null character if necessary.
- Example:

```
char f1[15] = "John ",
     f2[15] = "Jacqueline ",
     last[15] = "Kennedy";
strcat(f1, last);
strcat(f2, last);       /* invalid overflow */
strncat(f2, last, 3);
```


Characters vs. Strings

- The representation of a char (e.g., 'Q') and a string (e.g., "Q") is essentially different.
  - A string is an array of characters ended with the null character **'\0'**.

Character 'Q'



String "Q"

String Comparison

- Suppose there are two strings, str1 and str2.
  - The condition **str1 < str2** compare the **initial memory address** of str1 and of str2 --- nonsense
- The comparison between two strings is done by comparing each corresponding character in them.
  - The characters are compared based on their ASCII encoding.
  - "thr**i**ll" < "thr**o**w" since 'i' < 'o' lexicographic order
  - "joy" < "joy**ous**" since "joy" is a substring of "joyous"
- The standard string comparison uses the **strcmp** and **strncmp** functions.

String Comparison

Relationship	Returned Value	Example
str1 is less than str2	Negative	"Hello" is less than "Hi"
str1 equals str2	0	"Hi" equals "Hi"
str1 is greater than str2	Positive	"Hi" is larger than "Hello"

e.g., we can check if two strings are different by

```
if (strcmp(str1, str2) != 0)
   printf("The two strings are different!");
```


Sentinel-Controlled Loop for String Input

```
01 printf("Enter list of words on as many lines as you like.\n");
02 printf("Separate words by at least one blank.\n");
03 printf("When done, enter %s to quit.\n", SENT);
04
05 for  (scanf("%s", word);
06        strcmp(word, SENT) != 0;
07        scanf("%s", word)) {
08     /* process word */
09     . . .
10 }
```

Figure 9.10

Numeric vs. String Selection Sort

Numeric	String
Comparison (in function that finds index of the smallest among remaining elements)	

if (list[i] < list[first])
  first = i;
	if (**strcmp**(list[i], list[first]) < 0)
	  first = i;

Exchange of elements	

temp = list[index_of_min];
list[index_of_min] = list[fill];
list[fill] = temp;
	strcpy(temp, list[index_of_min]);
	strcpy(list[index_of_min], list[fill]);
	strcpy(list[fill], temp);

Data Areas

1. **strcpy(temp, list[index_of_min]);**
2. **strcpy(list[index_of_min], list[fill])**
3. **strcpy(list[fill], temp);**

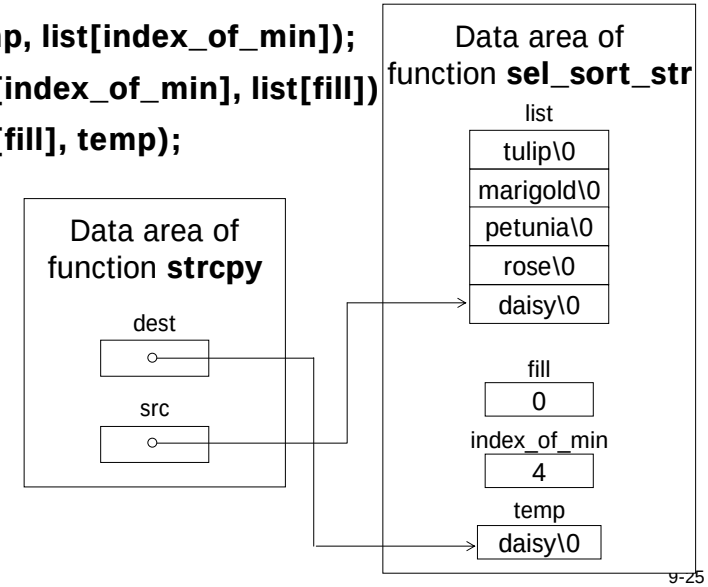


Figure 9.12

I/O of Characters and Strings

- The stdio library provides **getchar** function which gets the next character from the standard input.
  - **ch = getchar();** is the same as **scanf("%c", &ch);**
  - Other functions: **putchar**, **gets**, **puts**.
- For IO from/to the file, the stdio library also provides corresponding functions.
  - **getc**: reads a character from a file.
  - Other functions: **putc**, **fgets**, **fputs**.
- Unbuffered console IO: conio library
  - **getch**: read a char from keyboard instantly (does not require an additional **enter** key)

Scanning a Whole Line

- **gets**
  - Interactive input of one complete line of data
- Consider this code fragment:

```
char line[80];
printf("Type in a line of data.\n> ");
gets(line);
```

- The value stored in the array line would be

H	e	r	e		i	s		a		s	h	o	r	t		s	e	n	t	e	n	c	e	\0

- The **\n** character representing the <return> or <enter> key pressed at the end of the sentence is **NOT** stored when using gets().

Implementation of scanline Using getchar

```
01 /*
02  *  Gets one line of data from standard input.  Returns an empty string on
03  *  end of file.  If data line will not fit in allotted space, stores
04  *  portion that does fit and discards rest of input line.
05  */
06 char *
07 scanline(char *dest,     /* output - destination string */
08           int   dest_len) /* input  - space available in dest */
09 {
10     int i, ch;
11     /*  Gets next line one character at a time. */
12     i = 0;
13     for  (ch = getchar();
14           ch != '\n'  &&  ch != EOF   &&  i < dest_len - 1;
15           ch = getchar())
16        dest[i++] = ch;
17     dest[i] = '\0';
18     /*  Discards any characters that remain on input line */
19     while (ch != '\n'  &&  ch != EOF)
20        ch = getchar();
21     return (dest);
22 }
```

Figure 9.15

Scanning a Whole Line (cont'd)

- **fgets**
  - Three arguments
    1. Output parameter: string buffer
    2. Maximum number of characters to store (e.g. n)
       - Never store more than n-1 characters
       - Final character stored will always be '\0'
    3. File pointer to the data source stream
  - If it has room to store entire line, it will include '**\n**' before '**\0**', which is different from gets()
  - Return **0** means that it encounters the end of file (use feof() to test)
  - gets() is unsafe. Some compilers will warn you.

Scanning a Whole Line (cont'd)

```
01 #include <stdio.h>
02 #include <string.h>
03 #define LINE_LEN 80
04 #define NAME_LEN 40
05 int main(void) {
06     char line[LINE_LEN], inname[NAME_LEN], outname[NAME_LEN];
07     FILE *inp, *outp;
08     char *status;
09     int i = 0;
10     printf("Name of input file> ");
11     scanf("%s", inname);
12     printf("Name of output file> ");
13     scanf("%s", outname);
14     inp = fopen(inname, "r");
15     outp = fopen(outname, "w");
16     for  (status = fgets(line, LINE_LEN, inp);
17           status != 0;
18           status = fgets(line, LINE_LEN, inp)) {
19       if (line[strlen(line) - 1] == '\n')
20           line[strlen(line) - 1] = '\0';
21       fprintf(outp, "%3d>> %s\n\n", ++i, line);
22     }
23     return (0);
24 }
```

Figure 9.8

Scanning a Whole Line (cont'd)

Input file

In the early 1960s, designers and implementers of operating systems were faced with a significant dilemma. As people's expectations of modern operating systems escalated, so did the complexity of the systems themselves. Like other programmers solving difficult problems, the systems programmers desperately needed the readability and modularity of a powerful high-level programming language.

Output file

```
1>> In the early 1960s, designers and implementers of operating
2>> systems were faced with a significant dilemma. As people's
3>> expectations of modern operating systems escalated, so did
4>> the complexity of the systems themselves. Like other
5>> programmers solving difficult problems, the systems
6>> programmers desperately needed the readability and
7>> modularity of a powerful high-level programming language.
```


Array of Pointers

- char original[][9] = {"tulip","marigold","petunia","rose","daisy"};
  char *alphap[5];
  // char ** const alphap = (char **) malloc(5*sizeof(char *));

alphap[?] vs. original[?]

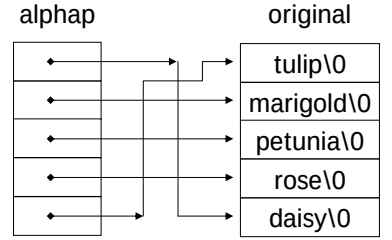


Figure 9.13

- alphap[i] refers to the same string as original[i].
- An array of pointers might represent a 2nd ordering
  - Pointer requires less space than a whole string
  - Executes faster
  - Accesses or modifications made through original[0] or alphap[4] are exactly the same.

2nd Ordering of a List

```
001 /*
002  *  Maintains two orderings of a list of applicants:  the original
003  *  ordering of the data, and an alphabetical ordering accessed through an
004  *  array of pointers.
005  */
006
007 #include <stdio.h>
008 #define STRSIZ 30  /*  maximum string length */
009 #define MAXAPP 50  /*  maximum number of applications accepted */
010
011 int alpha_first(char *list[], int min_sub, int max_sub);
012 void select_sort_str(char *list[], int n);
013
014 int main(void)
015 {                                          /* list of applicants in the */
016     char  applicants[MAXAPP][STRSIZ]; /*   order in which they applied */
017     char *alphap[MAXAPP];                  /* list of pointers to applicants */
018     int   num_app,                         /* actual number of applicants */
019           i;
020     char  one_char;
```

Figure 9.14

2nd Ordering of a List (cont'd)

```
022     /*  Gets applicant list   */
023     printf("Enter number of applicants (0 . . %d)\n> ", MAXAPP);
024     scanf("%d", &num_app);
025     do    /* skips rest of line after number */
026        scanf("%c", &one_char);
027     while (one_char != '\n');
028
029     printf("Enter names of applicants on separate lines\n");
030     printf("in the order in which they applied\n");
031     for (i = 0;  i < num_app; ++i)
032        gets(applicants[i]);
033
034     /*  Fills array of pointers and sorts */
035     for (i = 0;  i < num_app;  ++i)
036        alphap[i] = applicants[i];  /* copies ONLY address */
037     select_sort_str(alphap, num_app);
038
039     /*  Displays both lists   */
040     printf("\n\n%-30s%5c%-30s\n\n", "Application Order", ' ', "Alphabetical Order");
041     for (i = 0;  i < num_app;  ++i)
042        printf("%-30s%5c%-30s\n", applicants[i], ' ', alphap[i]);
043
044     return(0);
045 }
```


2nd Ordering of a List (cont'd)

```
046
047 /*
048  *  Finds the index of the string that comes first alphabetically in
049  *  elements min_sub..max_sub of list
050  *  Pre:  list[min_sub] through list[max_sub] are of uniform case;
051  *        max_sub >= min_sub
052  */
053 int alpha_first(char *list[],   /* input - array of pointers to strings   */
054                 int   min_sub,  /* input - minimum and maximum subscripts */
055                 int   max_sub)  /*   of portion of list to consider       */
056 {
057     int first, i;
058
059     first = min_sub;
060     for (i = min_sub + 1;  i <= max_sub;  ++i)
061        if (strcmp(list[i], list[first]) < 0)
062           first = i;
063
064     return (first);
065 }
```


2nd Ordering of a List (cont'd)

```
067 /*
068  *  Orders the pointers in array list so they access strings
069  *  in alphabetical order
070  *  Pre:  first n elements of list reference strings of uniform case; n >= 0
071  */
072 void                                   /* input/output - array of pointers being */
073 select_sort_str(char *list[],          /* ordered to access strings alphabetically */
074                 int   n)               /* input - number of elements to sort       */
075 {
076     int   fill,        /* index of element to contain next string in order */
077           index_of_min; /* index of next string in order */
078     char *temp;
079     for (fill = 0;  fill < n - 1;  ++fill) {
080        index_of_min = alpha_first(list, fill, n - 1);
081        if (index_of_min != fill) {
082           temp = list[index_of_min];
083           list[index_of_min] = list[fill];
084           list[fill] = temp;
085        }
086     }
087 }
```

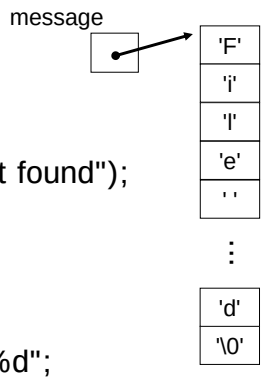
2nd Ordering of a List (cont'd)

```
Enter number of applicants (0 . . 50)
> 5
Enter names of applicants on separate lines
in the order in which they applied
SADDLER, MARGARET
INGRAM, RICHARD
FAATZ, SUSAN
GONZALES, LORI
KEITH, CHARLES
```

Application Order	Alphabetical Order
SADDLER, MARGARET	FAATZ, SUSAN
INGRAM, RICHARD	GONZALES, LORI
FAATZ, SUSAN	INGRAM, RICHARD
GONZALES, LORI	KEITH, CHARLES
KEITH, CHARLES	SADDLER, MARGARET

Naming a string constant

- Naming a string constant
  char *message = "File not found";
  or
  char *message;
  message = "File not found";
- Example 1:
  if (some error)
  printf(message); // printf("File not found");
- Errors: message[4] = ':';
  strcpy(message, "hello");
- Example 2:
  int result;
  char *format = "Here is the result: %d";
  ...
  printf(format, result);



Arrays of Strings

- C permits the use of an array of pointers to store a list of strings.
- For example
  - char month[12][10] = Two dimensional character array
    { "January", "February", "March", "April",
    "May", "June", "July", "August",
    "September", "October", "November", "December" };
  - char *month[12] = Array of char pointers to string constants
    { "January", "February", "March", "April",
    "May", "June", "July", "August",
    "September", "October", "November", "December" };

Character Analysis & Conversion

#include <ctype.h>

Facility	Checks	Example
isalpha	If argument is a letter of the alphabet	if (isalpha(ch)) printf("%c is a letter\n", ch);
isdigit	If argument is one of the ten decimal digits	dec_digit=isdigit(ch);

islower (isupper)	If argument is a lowercase (or uppercase) letter of the alphabet	if (islower(fst_let)) {
		printf("\nError: sentence");
		printf("should begin with a");
		printf("capital letter.\n")
		}

ispunct	If argument is a punctuation character	if (ispunct(ch)) printf("Punctuation mark: %c\n", ch)

Table 9.3

Character Analysis & Conversion

Facility	Converts	Example

isspace	If argument is a whitespace character	c=getchar();
		while (isspace(c) && c!=EOF)
		c=getchar();

tolower (toupper)	Its lowercase (or uppercase) letter argument to the uppercase (or lowercase) equivalent and returns this equivalent as the value of the call	if (islower(ch)) printf("Capital %c=%c\n", ch, toupper(ch))

Table 9.3

String – Number Conversion

- The <stdlib.h> defines some basic functions for conversion from strings to numbers:
  - **atoi("123")** converts a string to an integer.
  - **atol("123")** converts a string to a long integer.
  - **atof("12.3")** converts a string to a float.
- However, there is **no** functions such as itoa, itoa, ...etc,
  - because there is a function called **sprintf** which can converts many formats to a string.

sprintf and sscanf

- The **sprintf** function substitutes values for placeholders just as **printf** does except that it stores the result into a character array

```
int mon, day, year;
sprintf(s, "%d%d%d", mon, day, year);
```

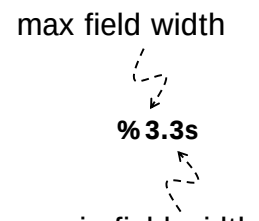
- The **sscanf** function works exactly like **scanf** except that it takes data from the string as its input argument.

```
int num; double val; char word[20];
sscanf("   85 96.2  hello", "%d%lf%s", &num, &val, word);
```


Placeholders Used with printf

Value	Placeholder	Outputs
'a'	%c %3c %-3c	a □□a a□□
-10	%d %2d %4d %-5d	-10 -10 □-10 -10□□
49.76	%.3f %.1f %10.2f %10.3e	49.760 49.8 □□□□□49.76 □4.976e+01
"fantastic"	%s %6s %12s %-12s **%3.3s**	fantastic fantastic □□□fantastic fantastic□□□ fan

Table 9.5



Date Format Conversion

```
001 /*
002  *  Functions to change the representation of a date from a string containing
003  *  day, month name and year to three integers (month day year) and vice versa
004  */
005
006 #include <stdio.h>
007 #include <string.h>
008
009 #define STRSIZ 40
010 char *nums_to_string_date(char *date_string, int month, int day,
011                                 int year, const char *month_names[]);
012 int search(const char *arr[], const char *target, int n);
013 void string_date_to_nums(const char *date_string, int *monthp,
014                                 int *dayp, int *yearp, const char *month_names[]);
015
016 /*  Tests date conversion functions       */
017 int
018 main(void)
019 {
020     char *month_names[12] = {"January", "February", "March", "April", "May",
021                              "June", "July", "August", "September",
022                              "October", "November", "December"};
023     int m, y, mon, day, year;
024     char date_string[STRSIZ];
```

Figure 9.18

Date Format Conversion (cont'd)

```
025     for  (y = 1993;  y < 2010;  y += 10)
026         for  (m = 1;  m <= 12;  ++m) {
027             printf("%s", nums_to_string_date(date_string,
028                                                 m, 15, y, month_names));
029             string_date_to_nums(date_string, &mon, &day, &year, month_names);
030             printf(" = %d/%d/%d\n", mon, day, year);
031         }
033     return (0);
034 }
036 /*
037  *  Takes integers representing a month, day and year and produces a
038  *  string representation of the same date.
039  */
040 char *
041 nums_to_string_date(char *date_string, /* output - string representation */
042                     int    month,      /* input  -                       */
043                     int    day,        /*   representation               */
044                     int    year,       /*   as three numbers             */
045                     const char *month_names[])
046 {                                   /* input  - string representations of months */
047     sprintf(date_string, "%d %s %d", day, month_names[month - 1], year);
048     return (date_string);
049 }
```


Date Format Conversion (cont'd)

```
051 #define NOT_FOUND -1  /* Value returned by search function if target
052                          not found */
053 /*
054  *  Searches for target item in first n elements of array arr
055  *  Returns index of target or NOT_FOUND
056  *  Pre:  target and first n elements of array arr are defined and n>0
057  */
058 int
059 search(const char *arr[],     /*  array to search     */
060        const char *target,    /*  value searched for */
061        int  n)                /*  number of array elements to search */
062 {
063     int i,
064         found = 0,     /*  whether or not target has been found */
065         where;         /*  index where target found or NOT_FOUND*/
```


Date Format Conversion (cont'd)

```
067     /*  Compares each element to target  */
068     i = 0;
069     while (!found && i < n) {
070         if (strcmp(arr[i], target) == 0)
071             found = 1;
072         else
073             ++i;
074     }
075
076     /* Returns index of element matching target or NOT_FOUND */
077     if (found)
078         where = i;
079     else
080         where = NOT_FOUND;
081     return (where);
082 }
```

Date Format Conversion (cont'd)

```
084 /*
085  *  Converts date represented as a string containing a month name to
086  *  three integers representing month, day, and year
087  */
088 void
089 string_date_to_nums(const char *date_string,   /* input - date to convert     */
090                     int        *monthp,        /* output - month number       */
091                     int        *dayp,          /* output - day number         */
092                     int        *yearp,         /* output - year number        */
093                     const char *month_names[])
094                     /* input - names used in date string */
095 {
096     char mth_nam[STRSIZ];
097     int  month_index;
098
099     sscanf(date_string, "%d%s%d", dayp, mth_nam, yearp);
100
101     /*  Finds array index (range 0..11) of month name. */
102     month_index = search(month_names, mth_nam, 12);
103     *monthp = month_index + 1;
104 }
```

15 January 1993 = 1/15/1993
15 February 1993 = 2/15/1993
. . .
15 December 2003 = 12/15/2003

Case Study: Text Editor

Step 1: **Problem**

- Design and implement a program to perform editing operations on a line of text.
- Your editor should be able to **locate** a specified target substring, **delete** a substring, and **insert** a substring at a specified location.
- The editor should expect source strings of less than 80 characters.

Text Editor (cont'd)

➢ Sample run Figure 9.21

```
Enter the source string:
> Internet use is growing rapidly.
Enter D(Delete), I(Insert), F(Find), or Q(Quit)> D
String to delete> growing
New source: Internet use is rapidly.

Enter D(Delete), I(Insert), F(Find), or Q(Quit)> F
String to find> .
'.' found at position 23
New source: Internet use is rapidly.

Enter D(Delete), I(Insert), F(Find), or Q(Quit)> I
String to insert>  expanding
Position of insertion> 23
New source: Internet use is rapidly expanding.

Enter D(Delete), I(Insert), F(Find), or Q(Quit)> Q
String after editing: Internet use is rapidly expanding.
```


Text Editor (cont'd)

Step 2: **Analysis**

- Problem Constant
  - MAX_LEN 100
- Problem Inputs
  - char source [MAX_LEN]
  - char command
- Problem Output
  - char source [MAX_LEN]

Text Editor (cont'd)

Step 3: **Design**

- Initial Algorithm
  1. Scan the string to be edited into source
  2. Get an edit command
  3. While command isn't Q
     4. Perform edit operation
     5. Get an edit command
- Refinement And Program Structure

  Local Variables

  char str[MAX_LEN]

  int index

Text Editor (cont'd)

Step 3: **Design**

- Algorithm for **do_edit**
  1. switch command

     '**D**' : 2. Get the substring to be deleted (str)
     3. Find the position of str in source
     4. if str is found, delete it

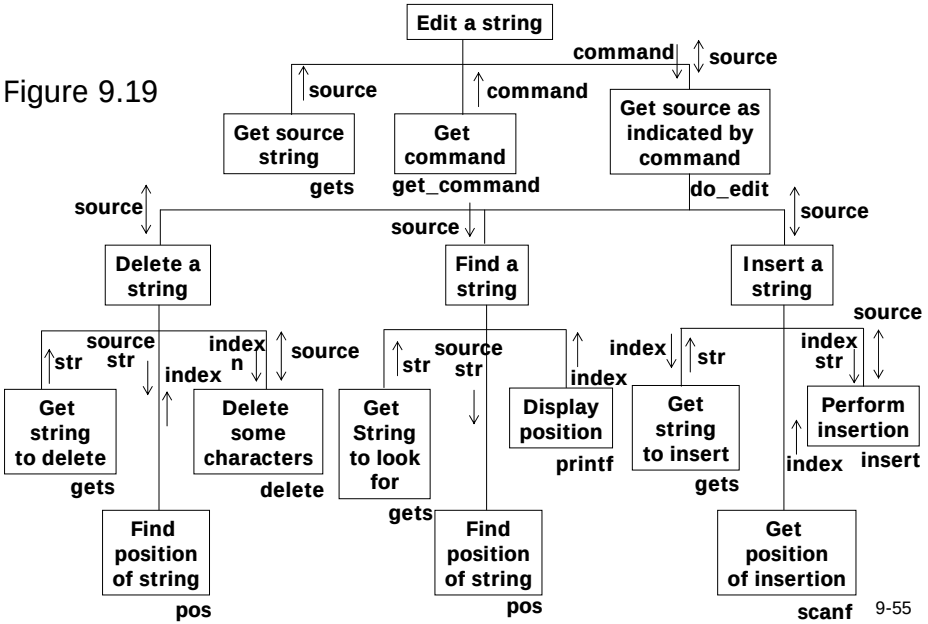
     '**I**' : 5. Get the substring to insert (str)
     6. Get position of insertion (index)
     7. Perform insertion of str at index position of source

     '**F**' 8. Get the substring to search for (str)
     9. Find the position of str in source
     10. Report position

     default: 11. Display error message

Structure Chart

Figure 9.19



Text Editor (cont'd)

Figure 9.20

```
001 /*
002  *  Performs text editing operations on a source string
003  */
004 #include <stdio.h>
005 #include <string.h>
006 #include <ctype.h>
007
008 #define MAX_LEN   100
009 #define NOT_FOUND -1
010
011 char *delete(char *source, int index, int n);
012 char *do_edit(char *source, char command);
013 char  get_command(void);
014 char *insert(char *source, const char *to_insert, int index);
015 int   pos(const char *source, const char *to_find);
016
017 int
018 main(void)
019 {
020       char source[MAX_LEN], command;
021
022       printf("Enter the source string:\n> ");
023       gets(source);
```

Text Editor (cont'd)

```
025     for (command = get_command();
026          command != 'Q';
027          command = get_command()) {
028         do_edit(source, command);
029         printf("New source: %s\n\n", source);
030     }
032     printf("String after editing: %s\n", source);
033     return (0);
034 }
035 /*
036  *  Returns source after deleting n characters beginning with source[index].  If
037  *  source is too short for full deletion, as many characters are deleted as possible.
039  *  Pre:  All parameters are defined and strlen(source) - index - n < MAX_LEN
041  *  Post:  source is modified and returned
042  */
043 char * delete(char *source, /* input/output-string from which to delete part */
045                int  index,      /* input - index of first char to delete        */
046                int  n)          /* input - number of chars to delete            */
047 {
048     char rest_str[MAX_LEN];  /* copy of source substring following
049                                 characters to delete */
```


Text Editor (cont'd)

```
051     /*  If there are no characters in source following, delete rest of string */
053     if (strlen(source) <= index + n) {
054          source[index] = '\0';
056     /*  Otherwise, copy the portion following the portion to delete
057         and place it in source beginning at the index position       */
058     } else {
059          strcpy(rest_str, &source[index + n]);
060          strcpy(&source[index], rest_str);
061     }
063     return (source);
064 }
065 /*
066  *  Performs the edit operation specified by command
067  *  Pre:  command and source are defined.
068  *  Post: After scanning additional information needed, performs a deletion
069  *        (command = 'D') or insertion (command = 'I') or finds a substring
070  *        ('F') and displays result; returns (possibly modified) source.
072  */
073 char *do_edit(char *source,  /* input/output - string to modify or search */
075                char  command) /* input - character indicating operation   */
076 {
077     char str[MAX_LEN];  /* work string */
078     int  index;
```


Text Editor (cont'd)

```
080     switch (command) {
081     case 'D':
082          printf("String to delete> ");
083          gets(str);
084          index = pos(source, str);
085          if (index == NOT_FOUND)
086               printf("'%s' not found\n", str);
087          else
088               delete(source, index, strlen(str));
089          break;
090
091     case 'I':
092          printf("String to insert> ");
093          gets(str);
094          printf("Position of insertion> ");
095          scanf("%d", &index);
096          insert(source, str, index);
097          break;
```


Text Editor (cont'd)

```
099     case 'F':
100          printf("String to find> ");
101          gets(str);
102          index = pos(source, str);
103          if (index == NOT_FOUND)
104               printf("'%s' not found\n", str);
105          else
106               printf("'%s' found at position %d\n", str, index);
107          break;
108
109     default:
110          printf("Invalid edit command '%c'\n", command);
111     }
112
113     return (source);
114 }
```

Text Editor (cont'd)

```
115 /*
116  *  Prompt for and get a character representing an edit command and
117  *  convert it to uppercase. Return the uppercase character and ignore
118  *  rest of input line.
119  */
120 char
121 get_command(void)
122 {
123       char command, ignore;
124
125       printf("Enter D(Delete), I(Insert), F(Find), or Q(Quit)> ");
126       scanf(" %c", &command);
127
128       do
129           ignore = getchar();
130       while (ignore != '\n');
131
132       return (toupper(command));
133 }
```


Text Editor (cont'd)

```
134 /*
135  *  Returns source after inserting to_insert at position index of  source.
136  *  If source[index] doesn't exist, adds to_insert at end of source.
138  *  Pre:  all parameters are defined, space available for source is enough to
139  *          accommodate insertion, and strlen(source) – index – n < MAX_LEN
141  *  Post: source is modified and returned
142  */
143 char *insert(char *source,          /* input/output - target of insertion   */
145                 const char *to_insert, /* input - string to insert          */
146                 int  index)          /* input - position where to_insert
147                                                  is to be inserted          */
148 {
149       char rest_str[MAX_LEN]; /* copy of rest of source beginning
150                                                  with source[index] */
152       if (strlen(source) <= index) {
153           strcat(source, to_insert);
154       } else {
155           strcpy(rest_str, &source[index]);
156           strcpy(&source[index], to_insert);
157           strcat(source, rest_str);
158       }
160       return (source);
161 }
```


Text Editor (cont'd)

```
162 /*
163  *  Returns index of first occurrence of to_find in source or
164  *  value of NOT_FOUND if to_find is not in source.
165  *  Pre:  both parameters are defined
166  */
167 int pos(const char *source,   /* input - string in which to look for to_find */
168           const char *to_find)  /* input - string to find                     */
169 {
170       int  i = 0, find_len, found = 0, position;
171       char substring[MAX_LEN];
172       find_len = strlen(to_find);
173       while (!found  &&  i <= strlen(source) - find_len) {
174           strncpy(substring, &source[i], find_len);
175           substring[find_len] = '\0';
176           if (strcmp(substring, to_find) == 0)
177                found = 1;
178           else
179                ++i;
180       }
181       if (found)
182            position = i;
183       else
184            position = NOT_FOUND;
185       return (position);
186 }
```


Common Programming Errors

- Figure 9.22 shows a poor rewrite of **scanline** function of Figure 9.15.
  - return the address of a deallocated variable: lifetime of a variable vs. scope of a variable

Flawed scanline

```
01 /*
02  *  Gets one line of data from standard input.  Returns an empty string on end
03  *  of file.  If data line will not fit in allotted space, stores portion that
04  *  does fit and discards rest of input line.
05  **** Error:  returns address of space that is immediately deallocated.
06  */
07 char *scanline(void)
08 {
09      char dest[MAX_STR_LEN];
10      int  i, ch;
11      /*  Get next line one character at a time. */
12      i = 0;
13      for  (ch = getchar();
14            ch != '\n'  && ch != EOF  &&  i < MAX_STR_LEN - 1;
15            ch = getchar())
16          dest[i++] = ch;
17      dest[i] = '\0';
18      /*  Discard any characters that remain on input line */
19      while (ch != '\n'  &&  ch != EOF)
20          ch = getchar();
21      return(dest);
22 }
```

Figure 9.22

returns address of a local variable

Programming Errors (cont'd)

- Misuse or neglect of the & operator
  - String is equivalent to "array of chars", the name of the array represents the address constant of the first element of the array
- Overflow of character arrays allocated for strings.
- All strings end with the null character, '\0'