Strings
Chapter 8

Problem Solving & Program Design in C

Eighth Edition

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Chapter Objectives

- To understand how a string constant is stored in an array of characters

- To learn about the placeholder %s and how it is used in printf and scanf operations

- To learn some of the operations that can be performed on strings such as copying strings extracting substrings, and joining strings using functions from the library string

String Basics

- null character
  - character '\0' that marks the end of a string in C
- A string in C is implemented as an array.
  - char string_var[30];
  - char str[20] = "Initial value";
- An array of strings is a 2-dimensional array of characters in which each row is a string.
- String library string.h

Input/Output

- printf and scanf can handle string arguments

- use %s as the placeholder in the format string

  char president[20];

  scanf("%s\n", president);

  printf("%s\n", president);

Initializing Strings

- sizeof() gives size in bytes
- strlen() gives length of string

char string[16] = "hello world";

char *str = "hello world";

char s[] = "hello world";

Initializing Strings

- sizeof() gives size in bytes
- strlen() gives length of string

char string[16] = "hello world";

| h | e | l | l | o | | w | o | r | l | d | \0 | | | | |

char *str = "hello world";

| 0x7ffc48aef660 | → | h | e | l | l | o | | w | o | r | l | d | \0 |

char s[] = "hello world";

| h | e | l | l | o | | w | o | r | l | d | \0 |

Initializing Strings

- sizeof() gives size in bytes
- strlen() gives length of string

char string[16] = "hello world";

sizeof() is 16
strlen() is 11

| h | e | l | l | o | | w | o | r | l | d | \0 | | | | |

char *str = "hello world";

sizeof() is 8
strlen() is 11

| 0x7ffc48aef660 | → | h | e | l | l | o | | w | o | r | l | d | \0 |

char s[] = "hello world";

| h | e | l | l | o | | w | o | r | l | d | \0 |

sizeof() is 12
strlen() is 11

String Terminology

- string length
  - in a character array, the number of characters before the first null character

J	o	h	n	?	?	?	?	?	?	?	?	?	?	?	?	?	?	?	?

- empty string
  - a string of length zero
  - the first character of the string is the null character

Scanning a Full Line

- For interactive input of one complete line of data, use the fgets function from stdio.

- Arguments: destination string, max characters to read, input

- Output: destination string or NULL if nothing read

- The \n character is stored if space.

fgets(<dest_string>, <num_chars>, <input>)

Strings Review 10/11

- In C, strings are…

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- In C, strings are…

- To store an array of strings, we need a…

- All strings must end with the…

- We can read in a full line (including spaces) as a string using the function…

String Assignment

- strcpy
  - copies string in second argument into its first argument
    - strcpy(s1, "hello");
  - subject to buffer overflow
- strncpy
  - takes an argument specifying the number of chars to copy
  - if the string to be copies is shorter, the remaining characters stored are null
    - strncpy(s2, "inevitable", 5);

= does not work!

String Comparison

a | b | l | u | e | \0 |

b | b | l | a | c | k | \0 |

c | b | l | u | e | \0 | ? | ? | ? | ? | ? |

d | b | l | u | e | \0 | ? | ? | ? | ? | ? | ? | ? | ? | ? | ? | ? | ? | ? | ? | ? |

String Comparison

TABLE 8.2   Possible Results of strcmp(str1, str2)

| Relationship	Value Returned	Example
str1 is less than str2	negative integer	str1 is "marigold" str2 is "tulip"
str1 equals str2	zero	str1 and str2 are both "end"
str1 is greater than str2	positive integer	str1 is "shrimp" str2 is "crab"

Buffer Overflow

- more data is stored in an array than its declared size allows

- a very dangerous condition

- unlikely to be flagged as an error by either the compiler or the run-time system

char string[8] = "hello world";

| h | e | l | l | o | | w | o | r | l | d | \0 |

String tokenization

```
char *last, *first, *middle;
char pres[20] = "Adams, John Quincy";
char pres_copy[20];
strcpy(pres_copy, pres);
```
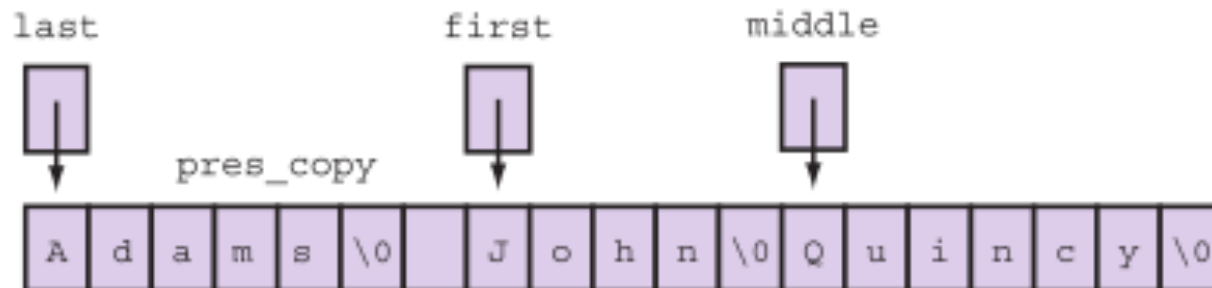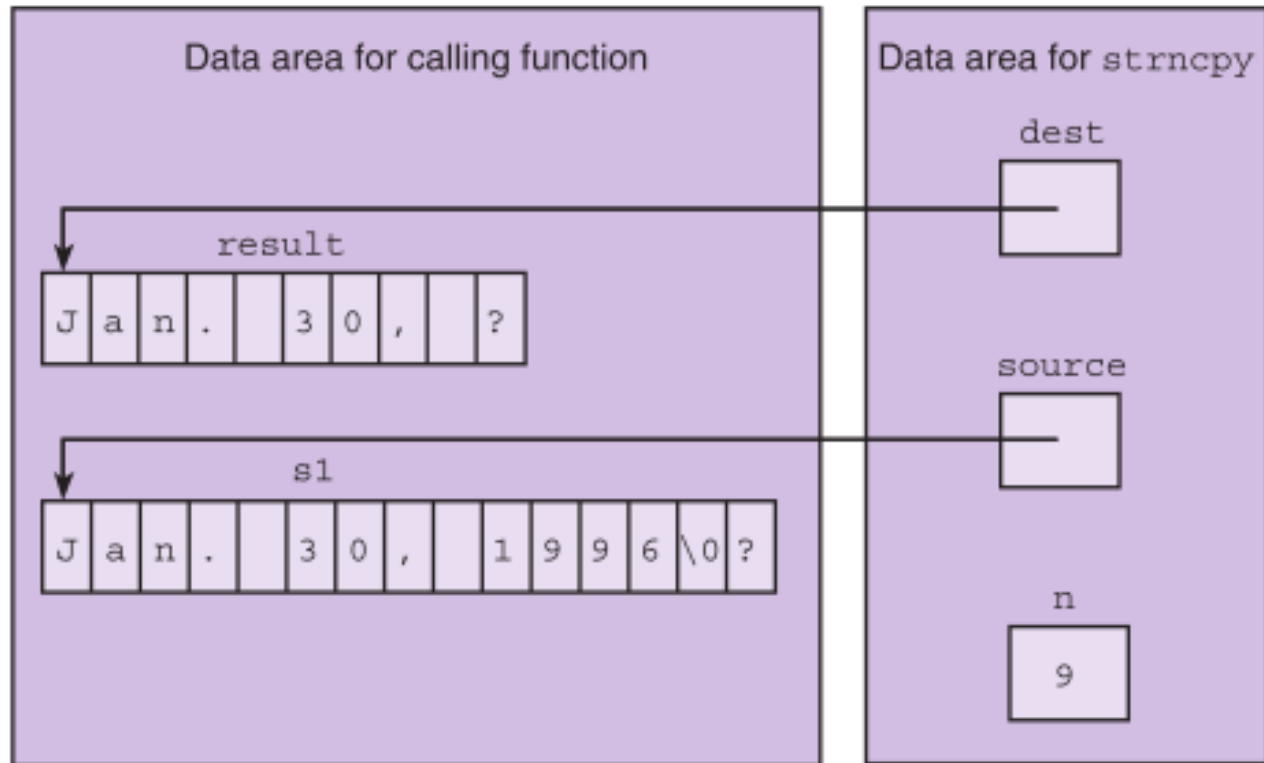


```
last = strtok(pres_copy, ", ");
first = strtok(NULL, ", ");
middle = strtok(NULL, ", ");
```
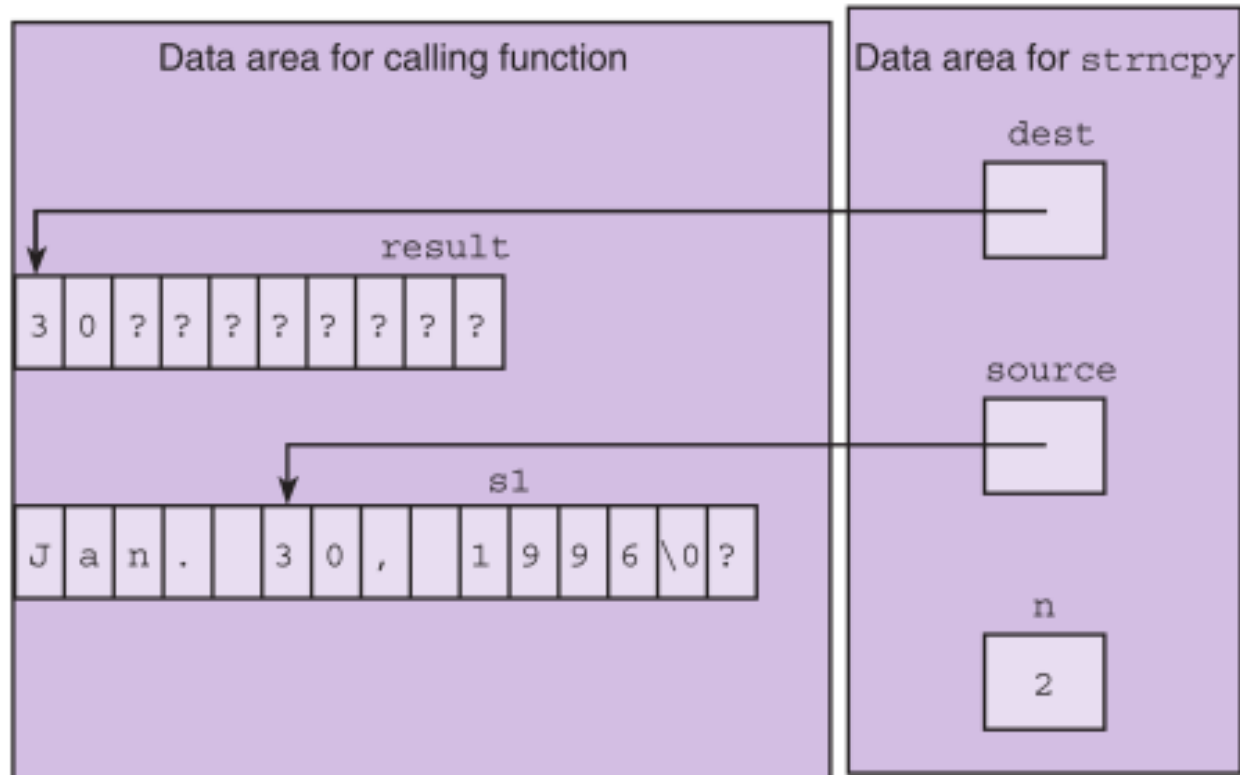
Substrings

FIGURE 8.5

Execution of
`strncpy(result, s1, 9);`

Substrings

FIGURE 8.6

Execution of
`strncpy(result,`
`&s1[5], 2);`

Substrings

```
char last [20], first [20], middle [20];
char pres [20] = " Adams , John Quincy ";
```

```
strncpy (last, pres, 5);
last [5] = '\0';
```

```
strcpy (middle, &pres[12]);
```

```
strncpy (first, &pres[7], 4);
first [4] = '\0';
```

Substrings

```
char last [20], first [20], middle [20];
char pres[20] = " Adams , John  Quincy ";
```

```
strncpy (last, pres, 5);
last[5] = '\0';
```

```
strcpy (middle, &pres[12]);
```

```
strncpy (first,  &pres[7], 4);
first[4] = '\0';
```

| J | o | h | n | \0 | ? | ? | ? | ? | ? | ? | ? | ? | ? | ? | ? | ? | ? | ? | ? |

Concatenation

- strcat
  - appends source to the end of dest
  - assumes that sufficient space is allocated for the first argument to allow addition of the extra characters
    - s1 = "hello";
    - strcat(s1, "and more");

| h | e | l | l | o | a | n | d | | m | o | r | e | \0 |

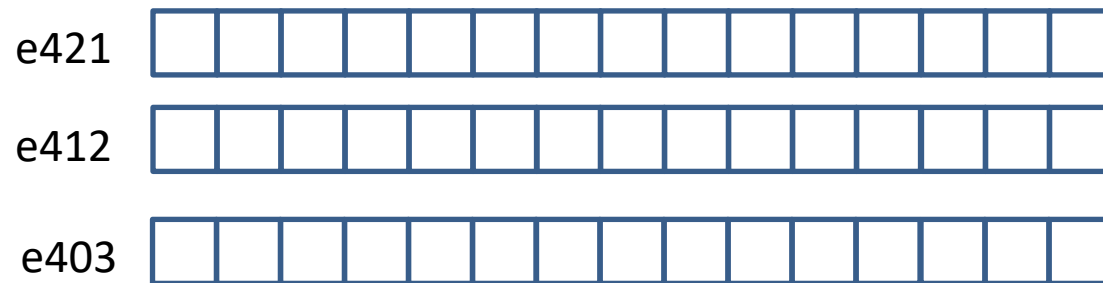# Concatenation

- strncat
  - appends up to n characters of source to the end of dest, adding the null character if necessary
  - assumes that sufficient space is allocated for the first argument to allow addition of the extra characters
    - s1 = "hello";
    - strncat(s1, "and more", 5);

h	e	l	l	o	a	n	d		m	\0	?

Concatenation

char k1[15] = "John ",

　　k2[15] = "Jacqueline ",

　　last[15] = "Kennedy";

strcat(k1,last);

strcat(k2,last);

e421

e412

e403

Concatenation

char k1[15] = "John ",

      k2[15] = "Jacqueline ",

      last[15] = "Kennedy";

strcat(k1,last);

strcat(k2,last);

e421	J	o	h	n		0									

e412	J	a	c	q	u	e	l	i	n	e		0			

e403	K	e	n	n	e	d	y	0							

Concatenation

char k1[15] = "John ",

     k2[15] = "Jacqueline ",

     last[15] = "Kennedy";

strcat(k1,last);

strcat(k2,last);

| e421 | J | o | h | n | | K | e | n | n | e | d | y | 0 | | |

| e412 | J | a | c | q | u | e | l | i | n | e | | 0 | | | |

| e403 | K | e | n | n | e | d | y | 0 | | | | | | | |

Concatenation

char k1[15] = "John ",

      k2[15] = "Jacqueline ",

      last[15] = "Kennedy";

strcat(k1,last);

strcat(k2,last);

| e421 | e | d | y | 0 | | K | e | n | n | e | d | y | 0 | | | overflow! |

| e412 | J | a | c | q | u | e | l | i | n | e | | K | e | n | n |

| e403 | K | e | n | n | e | d | y | 0 | | | | | | | |

Arrays of Pointers

- When sorting a list of strings, there is a lot of copying of characters from one memory cell to another.
  - 3 operations for every exchange
- C represents every array by its starting address.
- Consider an array of pointers, each element the address of a character string.

FIGURE 8.11   Exchanging String Elements of an Array

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

FIGURE 8.13

An Array
of Pointers
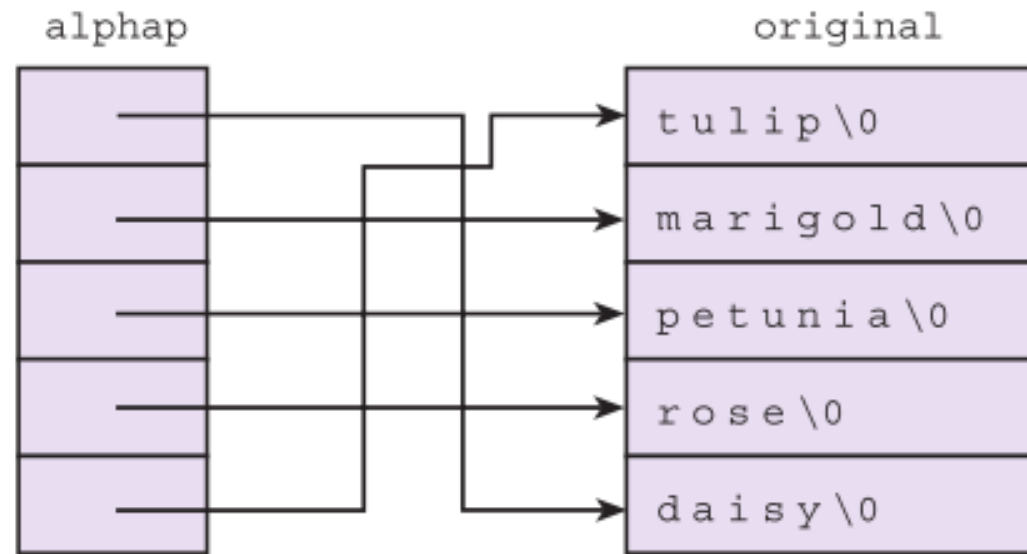
String-to-Number and Number-to-String Conversions

TABLE 8.4 Review of Use of scanf

Declaration	Statement	Data (▮ means blank)	Value Stored
char t	scanf("%c", &t);	▮g	
		\n	\n
		A	A
int n	scanf("%d", &n);	▮32▮	32
		▮▮−8.6	−8
		▮+19▮	19
double x	scanf("%lf", &x);	▮▮▮4.32▮	4.32
		▮−8▮	−8.0
		▮1.76e−3▮	.00176
char str[10]	scanf("%s", str);	▮▮hello\n overlengthy▮	hello\0 overlengthy\0 (overruns length of str)

String-to-Number and Number-to-String Conversions

TABLE 8.5 Placeholders Used with printf

Value	Placeholder	Output (▌ means blank)
'a'	%c	a
	%3c	▌▌a
	%-3c	a▌▌
-10	%d	-10
	%2d	-10
	%4d	▌-10
	%-5d	-10▌▌
49.76	%.3f	49.760
	%.1f	49.8
	%10.2f	▌▌▌▌▌49.76
	%10.3e	▌4.976e+01
"fantastic"	%s	fantastic
	%6s	fantastic
	%12s	▌▌▌fantastic
	%-12s	fantastic▌▌▌
	%3.3s	fan

String-to-Number and Number-to-String Conversions

- ## number to string: sprintf

    char s[20];
    int mon = 8, day = 23, year = 1914;
    sprintf(s, "%d/%d/%d", mon, day, year);

- ## string to number: sscanf

    int num;
    double val;
    char word[10];
    sscanf("85 96.2 hello", "%d%lf%s", &num, &val, word);

Things to remember

- Strings are just arrays of characters
- The string.h library provides functions for working with strings
- String variables are character pointers