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
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char s[] = “hello world”;

Initializing Strings

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

char string[16] = “hello world”;

sizeof() is 16
strlen() is 11

char *str = “hello world”;

sizeof() is 8
strlen() is 11

char s[] = “hello world”;

sizeof() is 12
strlen() is 11

String Terminology

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

- 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>)

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

c

d

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"`

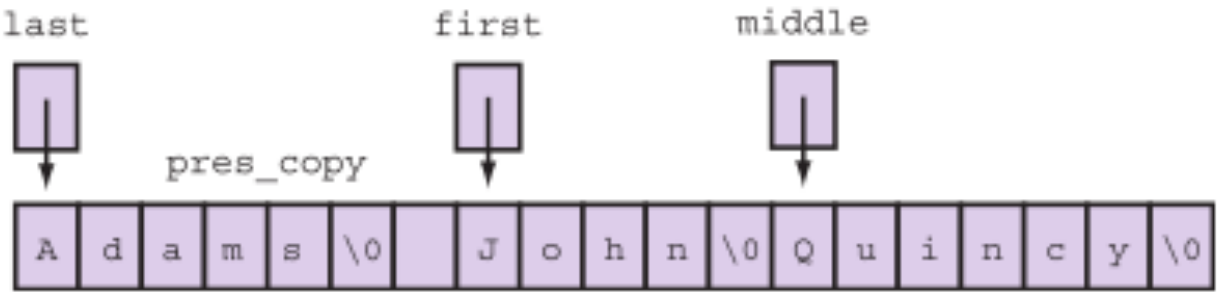
Buffer Overflow

- 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”;

String tokenization

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

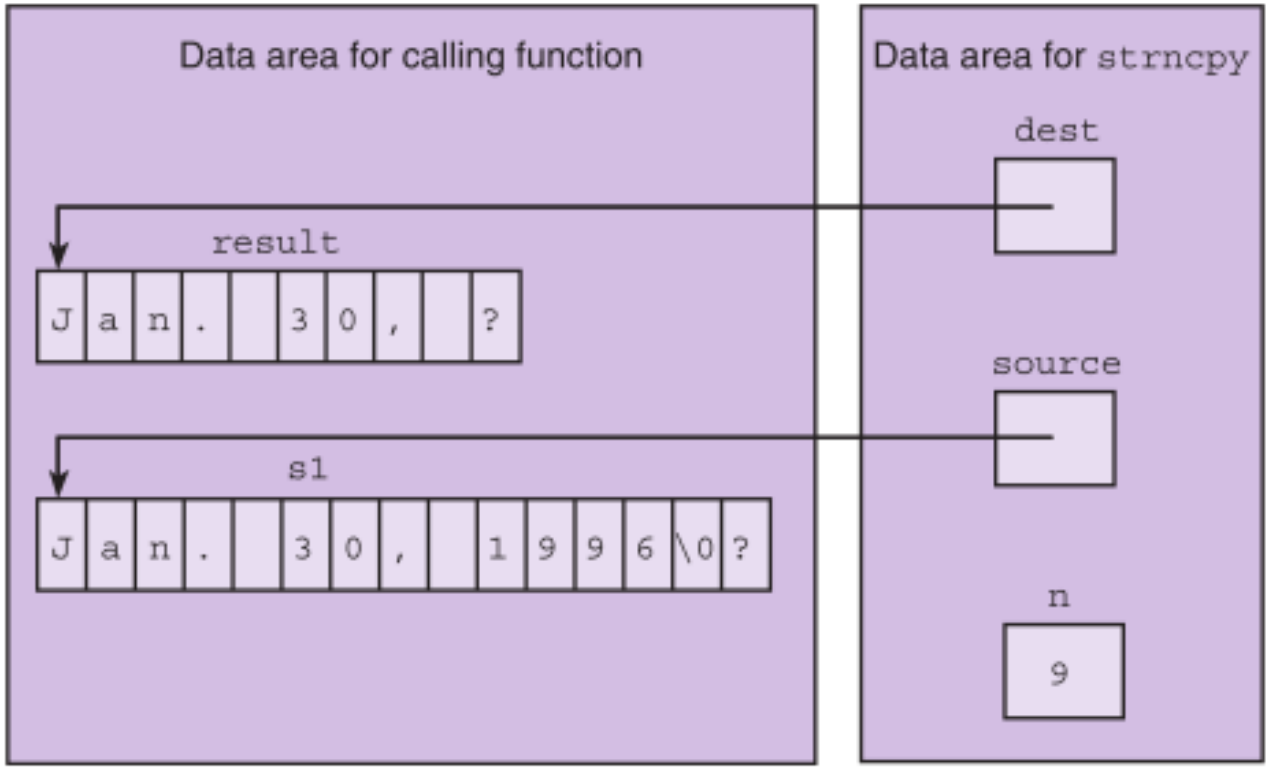



```
last = strtok(pres_copy, ", ");
first = strtok(NULL, ", ");
middle = strtok(NULL, ", ");
```

Substrings

FIGURE 8.5

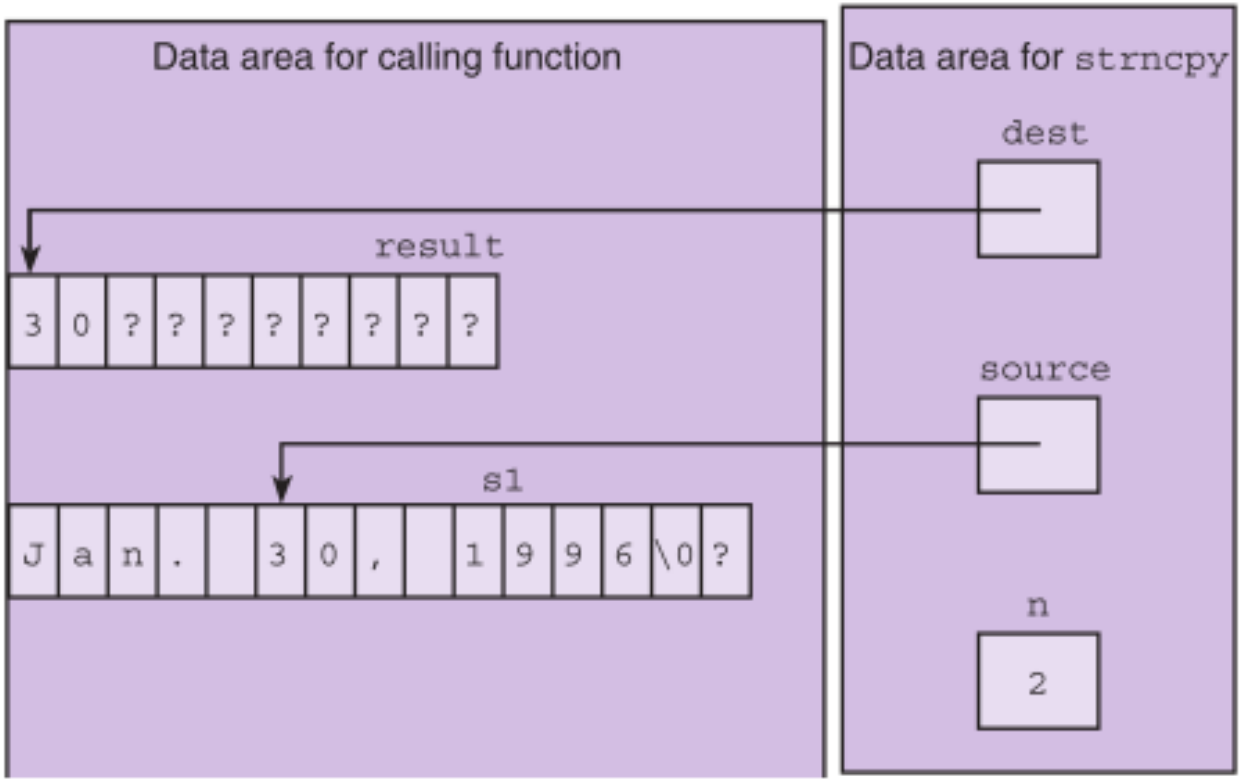
Execution of `strncpy(result, s1, 9);`



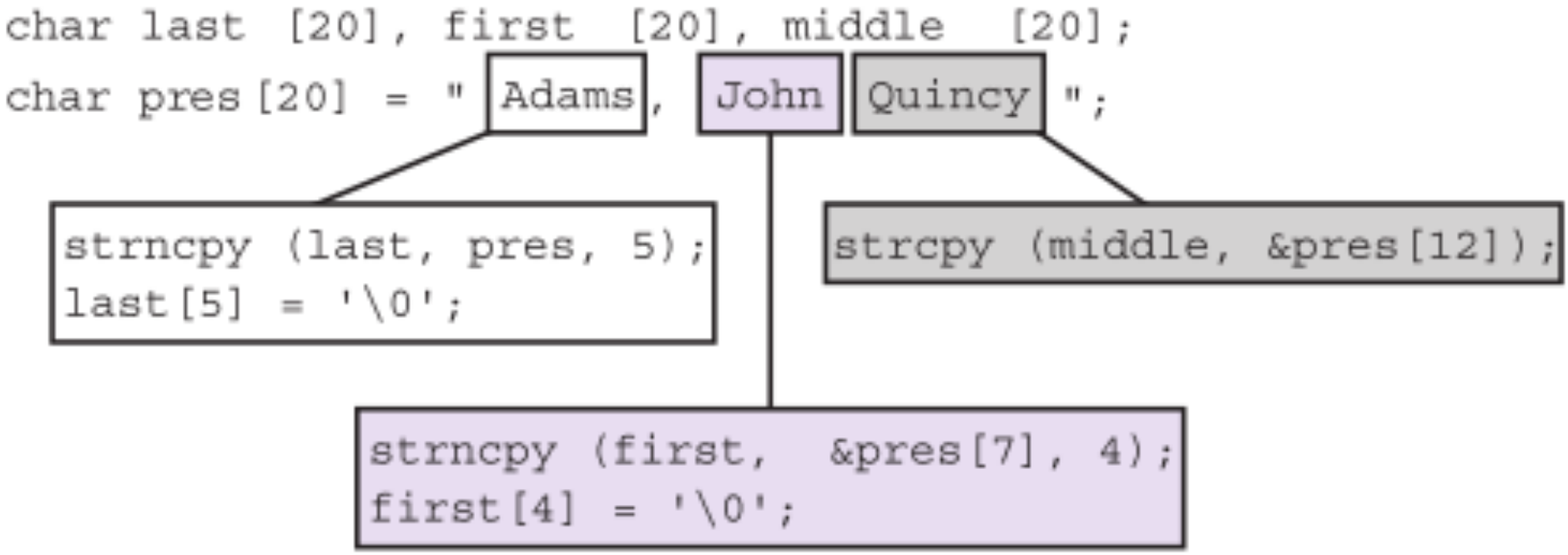
Substrings

FIGURE 8.6

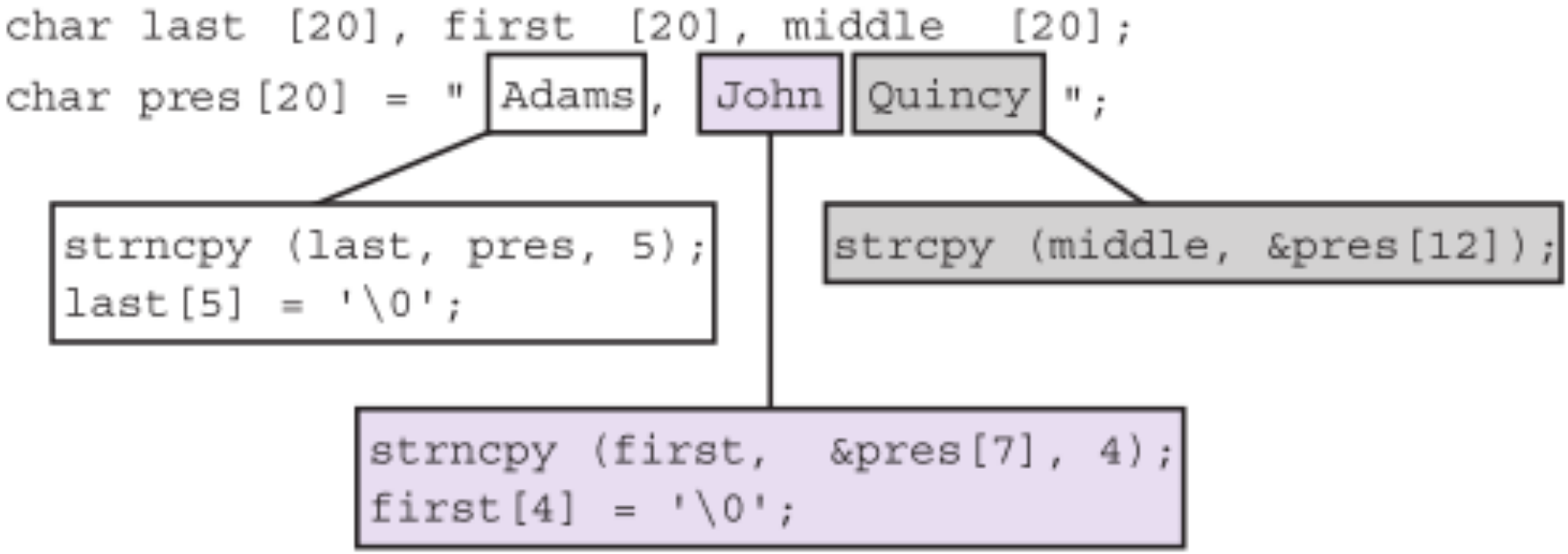
Execution of `strncpy(result, &s1[5], 2);`



Substrings



Substrings



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

Arrays of Pointers

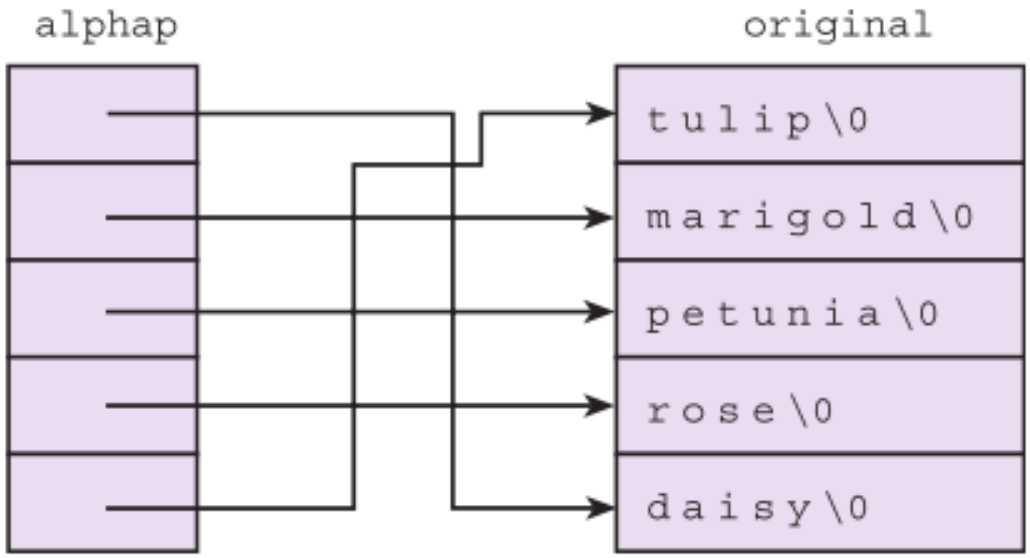
- When sorting a list of strings, there is a lot of copying of characters from one memory cell to another.
  - 3 operations for every exchange
- C represents every array by its starting address.
- Consider an array of pointers, each element the address of a character string.

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

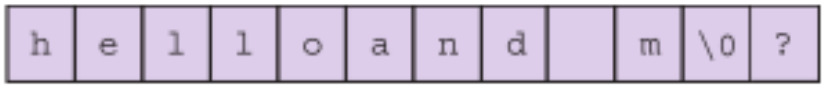


Concatenation

- 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”);

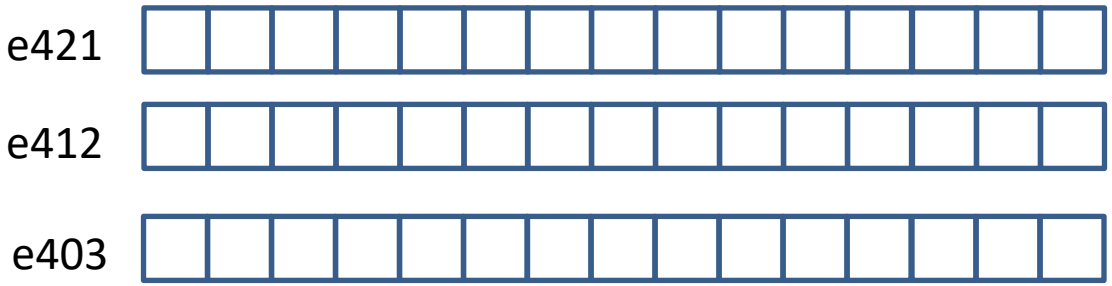
Concatenation

- 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);



Concatenation

```
char k1[15] = “John “,
        k2[15] = “Jacqueline “,
        last[15] = “Kennedy”;
strcat(k1,last);
strcat(k2,last);
```



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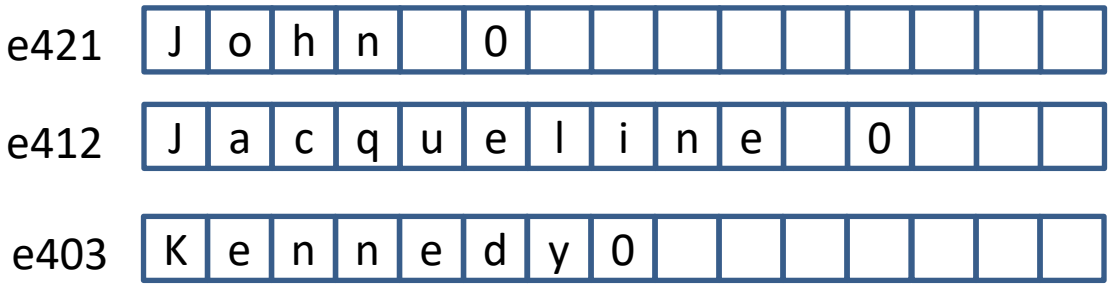

Concatenation

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strcat(k1,last);
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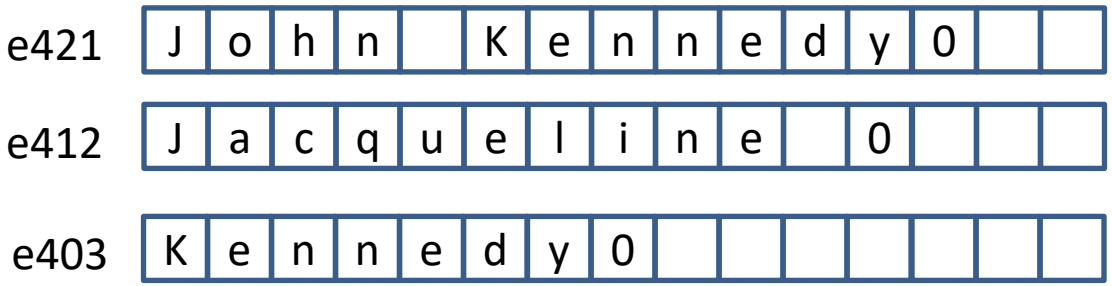
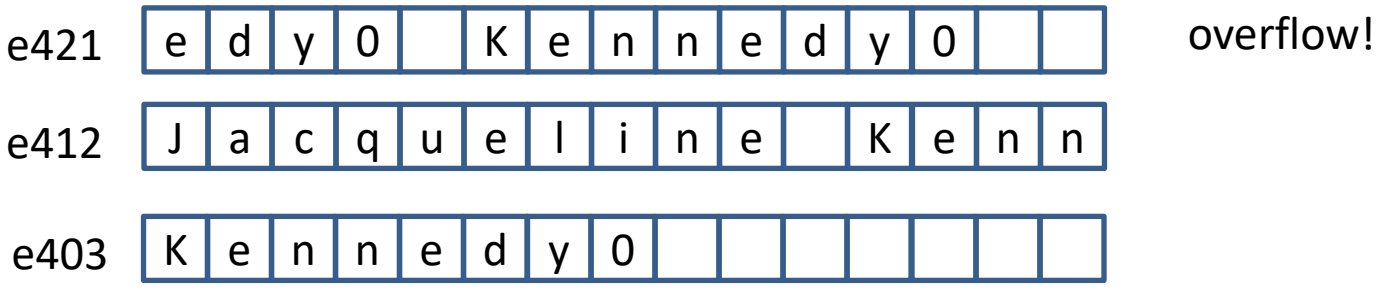
```



Concatenation

```
char k1[15] = “John “,
        k2[15] = “Jacqueline “,
        last[15] = “Kennedy”;
strcat(k1,last);
strcat(k2,last);
```



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`
		`A`
			
			`\n`
			`A`

`int n`	`scanf("%d", &n);`	`␣32␣`
		`␣␣-8.6`
		`␣+19␣`
			`32`
			`-8`
			`19`

`double x`	`scanf("%lf", &x);`	`␣␣␣4.32␣`
		`␣-8␣`
		`␣1.76e-3␣`
			`4.32`
			`-8.0`
			`.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