CSE 142
Computer Programming I

Strings

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Overview

Concepts this lecture

- **String constants**
- **Null-terminated array representation**
- **String library <string.h>**
- **String initializers**
- **Arrays of strings**

Chapter 9

Read Sections 9.1, 9.2, and 9.4:

- **9.1: String Basics**
- **Table 9.1 for summary of common functions**
- **9.2: String Assignment**
- **9.3: String Concatenation**
- **9.4: String Comparison**

Character Data in Programs

Names, messages, labels, headings, etc.

All of these are common in computer applications

All involve characters: usually multiple characters

So far, our ability to handle these things in C is very limited

Characters and Strings

Character constants (literals): single quotes

'a', 'A', '0', '1', '\n', ' ', 'B', 'i', 'l' , '\0'

null character

String constants (literals): double quotes

"Bill is very rich"

"The answer is %.2f. \n"

String Representation

Strings are stored in char arrays
Programming convention: a null character '\0' is stored at the end

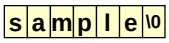
string	representation
"sample"	s a m p l e \0

'\0' in Strings

'\0' is not included in strings automatically

'\0' is included in string constants automatically

Programmer must take pains to be sure '\0' is present elsewhere when needed



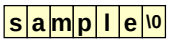
Leaving Room for '\0'

Character arrays holding strings must have room for '\0' following the actual data

The empty string "" occupies 1 char

Character and string constants are not the same:

'x' and "x" are different. How?

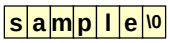


String Operations

Common needed operations:

- Copy (assignment)
- Compare
- Find length
- Concatenate (combine strings)
- I/O

Unfortunately...



What You Can't Do

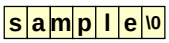
Strings are arrays

They have the limitations of arrays

Can't assign one string to another with =

Can't compare strings with ==, <=

But there are library functions to help do such things



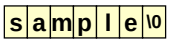
String Library: <string.h>

Standard C includes a library of string functions

use *#include <string.h>*

Library functions:

- Require proper null-terminated ('\0') strings as arguments
- Produce null-terminated strings as results (usually)



String Length: *strlen*

strlen returns the length of its string argument

Does not count the null '\0' at the end

Examples:

The length of "A" is 1

The length of "" is 0

```
k = strlen("null-terminated string");
```

stores 22 in *k*

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A *strlen* implementation

```
/*
 *   return the length of string  s, i.e.,
 *    number of characters before terminating '\0',
 *    or equivalently, index of first '\0'.
*/
int strlen( char s[ ] ) {
    int n = 0;
    while ( s[n]  != '\0') {
       n = n + 1 ;
    }
    return n;
}
```

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String Assignment: *strcpy*

strcpy(dest, source);

Copies characters from *source* to *dest*

- Copies up to, and including the first '\0' found
- Be sure that *dest* is large enough to hold the result!

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String Assignment: Examples

```
#include <string.h>
...
char medium[21] ;
char big[1000] ;
char small[5] ;
strcpy(medium, "Four score and seven" ) ;
```

medium: `Four score and seven\0`

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String Assignment: Examples

```
char medium[21 ];
char big[1000];
char small[5];
strcpy(big, medium);
strcpy(big, "Bob");
```

big: `Four score and seven\0?????...`

big: `Bob\0 score and seven\0?????...`

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String Assignment Dangers

```
char medium[ 21];
char big[1000] ;
char small[5] ;
strcpy(small, big) ;
strcpy(small, medium) ;    /* looks like trouble... */
```

small: `Bob\0?`

small: `Four score and seven\0`

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A *strcpy* implementation

```
/* copy source string into dest, stopping with '\0' */
void strcpy(char dest[ ], char source[ ]) {
    int i = 0;
    while (source[ i ]  != '\0') {
       dest[ i ] = source[ i ] ;
       i ++;
    }
    dest[ i ] = '\0' ;
}
```

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Appending and Concatenation

To append means to place one string directly after another

"chop" appended to "lamb" should result in "lambchop"

Also referred to as concatenation

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String Concatenation: *strcat*

<string.h> function:

strcat(dest, source);

Appends characters from *source* to *dest*
- Copy is stored starting at first '\0' in *dest*
- Copies up to, and including the first '\0' in *source*
- Be sure that *dest* is large enough!

T-20

Using *strcat* (1)

```
#include <string.h>
...
char str1[5] , str2[5] , str3[11];

strcpy(str1, "lamb");
strcpy(str2, "chop");
```

str1	l a m b \0
str2	c h o p \0
str3	? ? ? ? ? ? ? ? ? ? ?

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Using *strcat* (2)

```
strcpy(str3, str1);
strcat(str3, str2);
```

str1	l a m b \0
str2	c h o p \0
str3	l a m b c h o p \0 ? ?

T-22

String Comparison: *strcmp*

strcmp(s1, s2);

Compares *s1* to *s2* and returns an int describing the comparison

Negative if *s1* is less than *s2*
Zero if *s1* equals *s2*
Positive if *s1* is greater than *s2*

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Comparing Strings

strcmp compares corresponding characters until it finds a mismatch.

"lamb" is less than "wolf"

"lamb" is less than "lamp"

"lamb" is less than "lambchop"

T-24

Using *strcmp* (1)

Don't treat the result of *strcmp* as a Boolean!

Test the result as an integer

```
if (strcmp(s1,s2) == 0) {
        printf("same\n");
}
```

T-25

Using *strcmp* (2)

If you treat the result of *strcmp* as a Boolean, it might not do what you expect

```
if (strcmp(s1,s2)) {
        printf("yikes!");
}
```

prints *yikes* if s1 and s2 are *different!*

T-26

String I/O

scanf and *printf* can read and write C strings
Format code is %s

printf assumes '\0' is present

scanf will automatically insert '\0' at the end
Be sure the array has room for it!

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Spot the Security Hole

```
#define MAX_INPUT 200
char buffer [MAX_INPUT];
…
scanf("%s", buffer);
```

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Many Functions in *<string.h>*

strcat, strncat	concatenation
strcmp, strncmp	comparison
strtod, strtol, strtoul	conversion

Lots of others: check your favorite reference.

Related useful functions in *<ctype.h>*

operations on a single char:
convert case (to upper or lower)
check category (is char a number, etc.)
many others

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Using Libraries of Functions

To use strings effectively in C, use functions from string.h

Using libraries is very typical of C programming

- ANSI C standard libraries such as stdio.h, string.h, ctype.h, math.h
- Application-specific libraries: (thousands of them exist)

You can't be an effective programmer without being able to quickly master new libraries of functions

T-30

Bonus: String Initializers

```
char pet[5] = { 'l', 'a', 'm', 'b', '\0' } ;

char pet[5] ;
pet[0] = 'l' ;  pet[1] = 'a' ;  pet[2] = 'm' ;
pet[3] = 'b' ; pet[4] = '\0' ;

char pet[5] = "lamb" ;
```

all equivalent

But not:

```
char pet[5];
pet = "lamb" ;     /* No array assignment in C */
```

Remember that initializers are not assignment statements!

Bonus: Arrays of Strings

```
char month[12][10] = {
    "January",
    "February",
    ...
    "September",        /* longest month: 9 letters */
    ...
    "December" } ;
...
printf ("%s is hot \n", month[7] );     /* August */
```


Strings Summary

Definition: Null-terminated array of char

Strings are not fully a type of C
They share most limitations of arrays
***scanf/printf*: %s**
<string.h> library functions
- **Assignment: *strcpy***
- **Length: *strlen***
- ***strcat* and many others**

Major Pitfall: overrunning available space