Strings

Based on slides from K. N. King and Dianna Xu

Bryn Mawr College
CS246 Programming Paradigm

String Literals

- A ***string literal*** is a sequence of characters enclosed within double quotes:

```
"When you come to a fork in the road, take it."
```

- String literals may contain escape sequences.
- Character escapes often appear in `printf` and `scanf` format strings.
- For example, each `\n` character in the string

```
"Candy\nIs dandy\nBut liquor\nIs quicker.\n  --Ogden Nash\n"
```

causes the cursor to advance to the next line:

```
Candy
Is dandy
But liquor
Is quicker.
  --Ogden Nash
```

Continuing a String Literal

- The backslash character (\)

```
printf("When you come to a fork in the road, take it. \
--Yogi Berra");
```

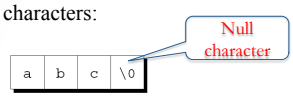
  - In general, the \ character can be used to join two or more lines of a program into a single line.
- When two or more string literals are adjacent, the compiler will join them into a single string.

```
printf("When you come to a fork in the road, take it. "
       "--Yogi Berra");
```

This rule allows us to split a string literal over two or more lines

How String Literals Are Stored

- The string literal `"abc"` is stored as an array of four characters:



- The string `""` is stored as a single null character:

How String Literals Are Stored

- Since a string literal is stored as an array, the compiler treats it as a pointer of type `char *`.
- Both `printf` and `scanf` expect a value of type `char *` as their first argument.
- The following call of `printf` passes the address of `"abc"` (a pointer to where the letter `a` is stored in memory):

```
printf("abc");
```

Operations on String Literals

- We can use a string literal wherever C allows a `char *` pointer:

```
char *p;

p = "abc";
```

- This assignment makes `p` point to the first character of the string.

Operations on String Literals

- String literals can be subscripted:

```
char ch;

ch = "abc"[1]; //ch is 'b'
```

- A function that converts a number between 0 and 15 into the equivalent hex digit:

```
char digit_to_hex_char(int digit)
{
  return "0123456789ABCDEF"[digit];
}
```

Operations on String Literals

- Attempting to modify a string literal causes undefined behavior:

```
char *p = "abc";

*p = 'd';   /*** WRONG ***/
```

- A program that tries to change a string literal may crash or behave erratically.

String Literals vs Character Constants

- A string literal containing a single character is not the same as a character constant.
  - `"a"` - represented by a *pointer*.
  - `'a'` - represented by an *integer*.
- A legal call of `printf`:

```
printf("\n");
```

- An illegal call:

```
printf('\n');   /*** WRONG ***/
```

String Variables

- Any one-dimensional array of characters can be used to store a string.
- A string must be terminated by a null character.

```
#define STR_LEN 80
…
char str[STR_LEN+1];
```

  - Defining a macro that represents 80 and then adding 1 separately is a common practice.

Initializing a String Variable

- A string variable can be initialized at the same time it's declared:

```
char date1[8] = "June 14";
char date4[] = "June 14";
```

Not a string literal. An abbreviation for an array initializer

date1	J	u	n	e		1	4	\0

```
char date2[9] = "June 14";
```

date2	J	u	n	e		1	4	\0	\0

Character Arrays vs Character Pointers

- The declaration

```
char date[] = "June 14";
```

Array name — Characters can be modified

declares `date` to be an *array*,

- The similar-looking

```
char *date = "June 14";
```

Pointer variable — String literal – should not be modified.

declares `date` to be a *pointer*.

- Thanks to the close relationship between arrays and pointers, either version can be used as a string.

Character Arrays vs Character Pointers

- `char *p;  //` does not allocate space for a string.
- Using an uninitialized pointer variable as a string is a serious error.

  An attempt at building the string "`abc`":

```
char *p;

p[0] = 'a';     /*** WRONG ***/
p[1] = 'b';     /*** WRONG ***/
p[2] = 'c';     /*** WRONG ***/
p[3] = '\0';    /*** WRONG ***/
```

- Before we can use `p` as a string, it must point to an array of characters.

```
char str[STR_LEN+1], *p;
p = str;
```

Reading and Writing Strings

- Writing a string
  - `printf`
  - `puts`
- Reading a string
  - in a single step
    - `scanf`
    - `gets`
  - read strings one character at a time.
- Reading a string is a bit harder, because the input may be longer than the string variable into which it's being stored.

`printf` and `puts`

- The `%s` conversion specification allows `printf` to write a string:

```
char str[] = "Are we having fun yet?";

printf("%s\n", str);
```

  The output will be

```
Are we having fun yet?
```

- `printf` writes the characters in a string one by one until it encounters a null character.

`printf` and `puts`

- A conversion specification: `%m.ps`
  - the first *p* characters of a string to be displayed in a field of size *m*.
- To print part of a string, use the conversion specification `%.ps`.
- `printf("%.6s\n", str); //Are we`
- The `%ms` conversion will display a string in a field of size *m*.
  - If the string has fewer than *m* characters, it will be right-justified within the field.
  - To force left justification instead, we can put a minus sign in front of *m*.

`printf` and Strings

```
int main() {
  char s[] = "01234";
  char *p;
  p = s;

  printf("%c\n", s[0]);
  printf("%c\n", *s);
  printf("%c\n", *(p+1));

  printf("%s\n", s);
  printf("%s\n", p+1);
}
```

- `%d`, `%c`, `%f`: Displays the given *value*
- `%s`: Displays characters from the specified *address* until `'\0'`

Displaying Substrings

```
int main() {
  char s[] = "01234";
  char *p;
  p = s;

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

  printf("%s\n", s + 0);
  printf("%s\n", &(s[0]));

  printf("%s\n", s + 2);
  printf("%s\n", &(s[2]));
}
```

Displaying Characters of a String

```
int main() {
  char s[] = "01234";
  char *p;
  p = s;

  printf("%c\n", s[0]);
  printf("%c\n", *p);
  printf("%c\n", *(p + 0));

  printf("%c\n", s[2]);
  printf("%c\n", *(p + 2));
}
```

printf and puts

```
puts(str);
```

- After writing a string, puts always writes an additional new-line character.

```
#define BUFLEN 200

int main() {
 char buf[BUFLEN];

  gets(buf);
  puts(buf);
  return 0;
}
```

puts adds '\n' to output, equivalent to `printf("%s\n", buf);`

scanf and gets

- The %s conversion specification allows scanf to read a string into a character array:

```
scanf("%s", str);
```

str is treated as a pointer no & in front of str

- When scanf is called,
  - it skips white space,
  - reads characters and stores them in str until it encounters a white-space character.
- scanf always stores a null character at the end of the string.

scanf and gets

- gets: read an entire line of input
- Properties of gets:
  - Does not skip white space before starting to read input.
  - Reads until it finds a new-line character.
  - Discards the new-line character instead of storing it; the null character takes its place.

scanf and gets

- Consider the following program fragment:

```
char sentence[SENT_LEN+1];

printf("Enter a sentence:\n");
scanf("%s", sentence);
```

- Suppose that the user enters the line

```
To C, or not to C: that is the question.
```

- scanf will store the string "To" in sentence.
- gets will store the string

```
" To C, or not to C: that is the question."
```

in sentence.

scanf and gets

- As they read characters into an array, scanf and gets have no way to detect when it's full.
- Consequently, they may store characters past the end of the array, causing undefined behavior.
- scanf: use the conversion specification %*n*s instead of %s.
- gets is inherently unsafe; fgets is a much better alternative.

Accessing the Characters in a String

- A function that counts the number of spaces in a string:

```
int count_spaces(const char s[])
{
  int count = 0, i;

  for (i = 0; s[i] != '\0'; i++)
    if (s[i] == ' ')
      count++;
  return count;
}
```

Accessing the Characters in a String

- A version that uses pointer arithmetic instead of array subscripting :

```
int count_spaces(const char *s)
{
  int count = 0;

  for (; *s != '\0'; s++)
    if (*s == ' ')
      count++;
  return count;
}
```