CSE105 – Structured Programming

String

Fundamentals of Characters and Strings

- Character constants: (which actually represents an integer value)

  `'a', 'A', '0', '1', '\n', ' ', '\0', ..`

- String constants:

  `"I am a student", "Your score %d\n"`

- Character variable to store a character

  ```
  char c = '1';
  ```

- Character array, which can store a string

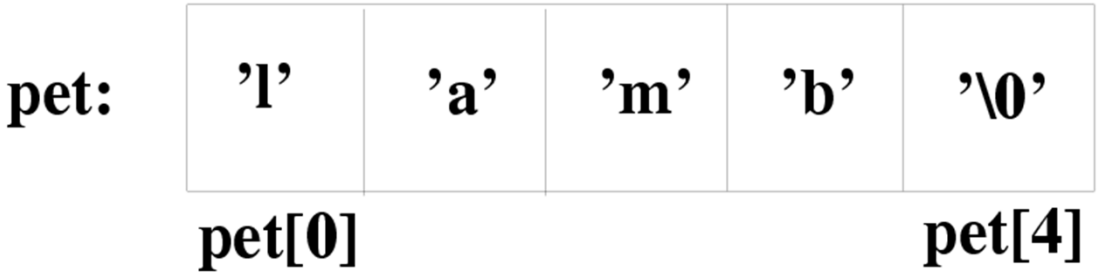
  ```
  char str[15] = "I am a student";
  ```

String Implementation and Representation

- Implemented by an array of characters

```
char pet[5] = {'l', 'a', 'm', 'b', '\0'};
printf("Mary has a little %s.\n", pet);
```

  - More accurate: NULL-terminated array of characters



- Represented by a character array

```
char color[] = "blue";
```

What is String

- Strings are arrays of characters in which a special character—the null character (‘\0’)—marks the end.
- The C library provides a collection of functions for working with strings.

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 (\) can be used to continue a string literal from one line to the next:

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

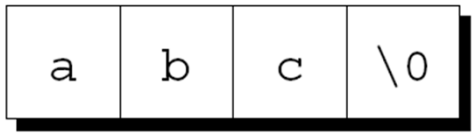
- In general, the \ character can be used to join two or more lines of a program into a single line.

How String Literals Are Stored

- When a C compiler encounters a string literal of length *n* in a program, it sets aside *n* + 1 bytes of memory for the string.
- This memory will contain the characters in the string, plus one extra character—the ***null character***—to mark the end of the string.
- The null character is a byte whose bits are all zero, so it's represented by the `\0` escape sequence.

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:

String Literals versus Character Constants

- A string literal containing a single character isn't the same as a character constant.
  - `"a"` is represented by a *pointer*.
  - `'a'` is 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.

String Variables

- If a string variable needs to hold 80 characters, it must be declared to have length 81:

  ```
  char str[80+1];
  ```

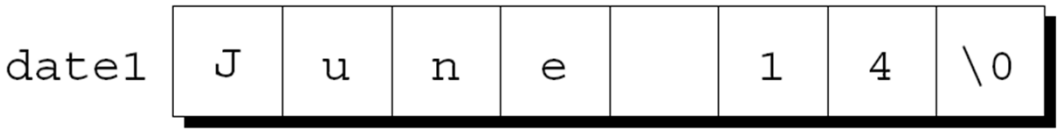
- Adding 1 to the desired length allows room for the null character at the end of the string.
- Failing to do so may cause unpredictable results when the program is executed.

Initializing a String Variable

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

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

- The compiler will automatically add a null character so that `date1` can be used as a string:

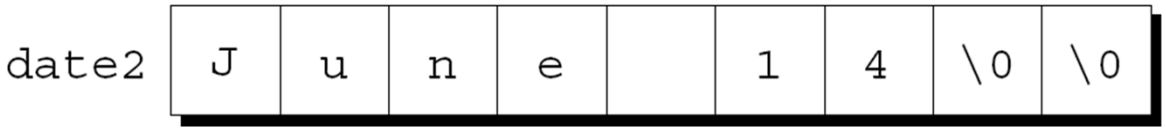


Initializing a String Variable

- If the initializer is too short to fill the string variable, the compiler adds extra null characters:

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

  Appearance of `date2`:

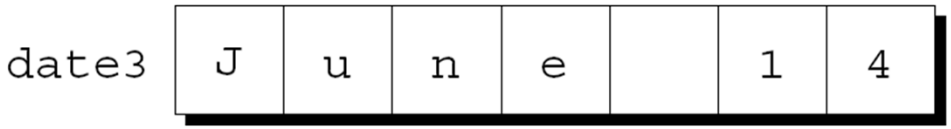


Initializing a String Variable

- An initializer for a string variable can't be longer than the variable, but it can be the same length:

```
char date3[7] = "June 14";
```

- There's no room for the null character, so the compiler makes no attempt to store one:



Initializing a String Variable

- The declaration of a string variable may omit its length, in which case the compiler computes it:

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

- The compiler sets aside eight characters for `date4`, enough to store the characters in `"June 14"` plus a null character.
- Omitting the length of a string variable is especially useful if the initializer is long, since computing the length by hand is error-prone.

Reading and Writing Strings

- Writing a string is easy using either `printf` or `puts`.
- To read a string in a single step, we can use either `scanf` or `gets`.
- As an alternative, we can read strings one character at a time.

Writing Strings Using `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.

Writing Strings Using `printf` and `puts`

- `printf` isn't the only function that can write strings.
- The C library also provides `puts`:

```
puts(str);
```

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

Reading Strings Using `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, so there's no need to put the & operator in front of `str`.
- When `scanf` is called, it skips white space, then 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.

Reading Strings Using `scanf` and `gets`

- `scanf` won't usually read a full line of input.
- A new-line character will cause `scanf` to stop reading, but so will a space or tab character.
- To read an entire line of input, we can use `gets`.
- Properties of `gets`:
  - Doesn't 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.

Reading Strings Using `scanf` and `gets`

- Consider the following program fragment:

```
char sentence[80+1];

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

- Suppose that after the prompt

```
Enter a sentence:
```

the user enters the line

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

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

Reading Strings Using `scanf` and `gets`

- Suppose that we replace `scanf` by `gets`:

  ```
  gets(sentence);
  ```

- When the user enters the same input as before, `gets` will store the string

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

  in `sentence`.

Reading Strings Character by Character

- Suppose we need a function that (1) doesn't skip white-space characters, (2) stops reading at the first new-line character (which isn't stored in the string), and (3) discards extra characters.
- A prototype for the function:

```
int read_line(char str[], int n);
```

- If the input line contains more than `n` characters, `read_line` will discard the additional characters.
- `read_line` will return the number of characters it stores in `str`.

Reading Strings Character by Character

- `read_line` consists primarily of a loop that calls `getchar` to read a character and then stores the character in `str`, provided that there's room left:

```
int read_line(char str[], int n)
{
  int i = 0;
  char ch;
  while ((ch = getchar()) != '\n')
    if (i < n)
      str[i++] = ch;
  str[i] = '\0';   /* terminates string */
  return i;        /* number of characters stored */
}
```

Reading Strings Character by Character

- Before returning, `read_line` puts a null character at the end of the string.
- Standard functions such as `scanf` and `gets` automatically put a null character at the end of an input string.
- If we're writing our own input function, we must take on that responsibility.

Accessing the Characters in a String

- Since strings are stored as arrays, we can use subscripting to access the characters in a string.
- To process every character in a string `s`, we can set up a loop that increments a counter `i` and selects characters via the expression `s[i]`.

Accessing the Characters in a String

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

```
int count_spaces()
{
   char s[1000];
  int count = 0, i;
   gets(s);
  for (i = 0; s[i] != '\0'; i++)
     if (s[i] == ' ')
        count++;
  return count;
}
```