Computer Programming: Skills & Concepts (CP)
Strings

Ajitha Rajan

Tuesday 31 October 2017

Last lecture

- Input handling
- `char`

Today's lecture

- Strings
- String I/O.
- String Comparison.

Strings

A *string* is any 1-dimensional character array that is terminated by a null character.

- Null is `'\0'`.
- For local use, we declare strings by `char *s = "thestring"` or `char s[11]`
- `char *s = "thestring"` declares a pointer variable that points to the first character of the (constant) string;
- whereas `char s[11]` declares an array of 11 characters.
- Strings are declared in *function arguments* either as `char *s` or `char s[]`.
  eg, `void foo(char *s)` or `void foo(char s[])`
  (meaning ... a pointer to a `char`)
- In declaring a string, array length must be 1 greater than the longest string it will hold, to allow for the null.
  eg, `char[11]` can hold a 10-character string.

`char *` and `char[]`

`char *a` makes space for a single pointer variable – it makes no space for the string.
`char b[]` makes space for the string (but makes no space for a pointer).

If you want a string to read into or modify, use `char[]`.

```
char b[] = "I can be written into";
char c[256]; // a nice big string to use
```

If you want a *constant* string (e.g. for messages), you can use `char *`.

```
char *a = "I can't be written into";
```

If you want a variable to refer to strings that already exist, use `char *`.

```
char *a;
```

See end of lecture for gory details.

The string library

- Need to include it at the start:
  - `#include <string.h>`
- To copy a string `s2` into `s1`:
  - `strcpy(s1,s2);` `strcpy(s1,"Hello\n");`
- To add `s2` onto the end of `s1`:
  - `strcat(s1,s2)`
- Returns the length of `s1`:
  - `strlen(s1)`
- Many others . . .

The string library – types

```
char *strcpy(char *p1, const char *p2);
```

Returns the pointer `p1`

```
char *strcat(char *p1, const char *p2)
```

likewise

```
size_t strlen(const char *p1)
```

`size_t` *is a system-dependent type. On DICE PCs it is an* `unsigned long int`*, i.e. an 8-byte integer.*

The string library – types

```
char *strcpy(char *p1, const char *p2);
```

Returns the pointer `p1`

```
char *strcat(char *p1, const char *p2)
```

likewise

```
size_t strlen(const char *p1)
```

`size_t` *is a system-dependent type. On DICE PCs it is an* `unsigned long int`*, i.e. an 8-byte integer.*

WARNING: When using `strcat` or `strcpy`, it is **your** responsibility to make sure `p1` has enough space. E.g:

```
char a[5];
strcpy(a,"This string is too long");
```

will segfault, or worse, overwrite some other data.

String I/O

(don't need `<string.h>` for these)

- To `printf` a string: `printf("%s", s1);`
- To read in a string:
  - `scanf("%s", s1);` `/* ?why no & on s1? */`

Write/Read from a *string* (not I/O stream):

- To print a float `a` into a string `s1`:
  - `sprintf(s1,"hello, num=%f", a);`
  - `sprintf` returns an integer, being the number of `chars` written;
  - make sure `s1` has space.
- Similarly, we can read ints/floats etc; from a string via `sscanf`:
  - `int sscanf(s1, "%d Montgomery St", &door);`
  - Value returned is the number of variables assigned to.

What about <, <=, == etc on strings?

```
int main(void) {
  char sone[] = "hiya";
  char stwo[] = "cp";
  char sthr[] = "coders";
  if (sone <= stwo) {
    printf("\"hiya\" is less than or equal to \"cp\".\n");
  } else {
    printf("\"cp\" is less than \"hiya\".\n");
  }
  if (stwo <= sthr) {
    printf("\"cp\" is less than or equal to \"coders\".\n");
  } else {
    printf("\"coders\" is less than \"cp\".\n");
  }
  return EXIT_SUCCESS;
}
```

`<`, `<=`, `==` don't work for strings

`(sone <= stwo)`

- `sone` and `stwo` are *pointers* to `char` variables (ie, are addresses in memory).
- comparison is true is and only if address in `sone` is less than `stwo`.

Output is *unpredictable*: compiler is free to allocate memory addresses for variables

. . . in order of declaration in the program, or maybe

. . . combination of declaration order and string length, or maybe

. . . in reverse order of declaration in program, or even

. . . in lexicographic order of initialization string (if given).

strcmp

```
int strcmp(const char *s1, const char *s2);
```

returns 0 if `s1` and `s2` are equal,
a negative int if string `s1` is *lexicographically* less than `s2`
a positive int if string `s1` is *lexicographically* greater than `s2`

```
...
if (strcmp(sone, stwo) <= 0) {
  printf("\"%s\" is less than or equal to \"%s\".\n", sone, stwo)
} else {
  printf("\"%s\" is greater than \"%s\".\n", sone, stwo);
}
```

Comparing arrays of other types

A string is a `char` array. What about comparing arrays of `int`s or `float`s?

```
int memcmp (const void *a1, const void *a2, size_t size);
```

- `memcmp` compares the `size` bytes of memory beginning at `a1` against the `size` bytes of memory beginning at `a2`.
- Value returned has the same sign as the difference between the *first differing pair of bytes*.
- For this reason, only useful for testing *equality*, not relative order.

What is this `void *` type? `void` is a type that nothing can be! But `void *` is used as a generic pointer type: a `void *` can be cast to any other pointer type.

strncpy and friends

The requirement to ensure that s1 has enough space in strcpy(s1,s2) etc. is tedious – have to check length of s2. Frequent cause of 'buffer overflows' and security exposures.
For safety, all professionally written C code uses:

```
char *strncpy(char *dest, const char *src, size_t n);
```

which copies at most n characters of src. Example:

```
/* 50 character strings (excl. null) */
#define LEN 50
char s[LEN+1]; /* add one for the null */

strncpy(s,maybe_long_string,LEN);
s[LEN] = '\0'; /* make sure there's a null at the end */
```

Similarly for strncat, snprintf and so on.

`char *` and `char[]`

What's the difference between

```
char *a = "foo1";
char b[] = "foo2";
```

`a` is a variable, holding a pointer to the first character of `"foo1"`.
You can assign to it: `a = "bar";`

`b` *is* a pointer to the first character of `"foo2"`.
You can't assign to it. `b = "bar";` is a *compile-time* error.

Can you modify the contents of the string?

`char *` and `char[]`

What's the difference between

```
char *a = "foo1";
char b[] = "foo2";
```

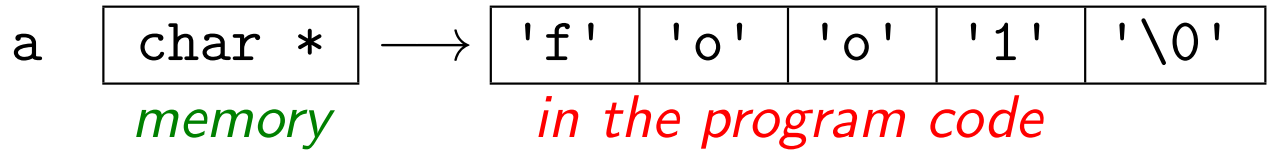
`a` is a variable, holding a pointer to the first character of `"foo1"`.
You can assign to it: `a = "bar";`

`b` *is* a pointer to the first character of `"foo2"`.
You can't assign to it. `b = "bar";` is a *compile-time* error.

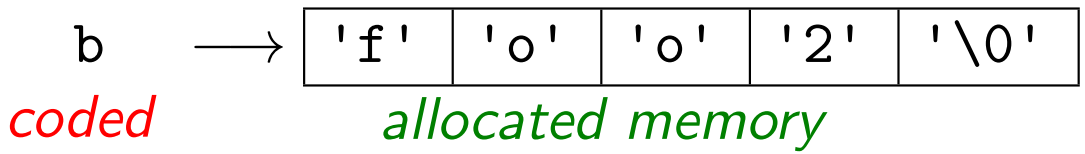
Can you modify the contents of the string?
`strcpy(b,"bar");` is ok, because `b` is an array of characters.
`strcpy(a,"bar");` fails *at run-time*, because `a` is a pointer to (the first character of) the *literal* string `"foo1"`, and (reasonably enough) you can't change a literal string!
(But `a = b; strcpy(a,"bar");` is fine.)

char * and char[]

```
char *a = "foo1";
```




```
char b[] = "foo2";
```



In fact, `char b[] = "foo2";` is effectively a convenient abbreviation for

```
char b[sizeof("foo2")];
strcpy(b,"foo2");
```

and `b` is an abbreviation for `&b[0]`, the address of the first of the allocated character cells.

Assigned Reading (Kelley and Pohl)

For Strings: §6.10, §6.11, Appendix A.14