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CS 333

Intro to Operating Systems
Command-Line Arguments

```
int main(int argc, char *argv[], char **envp)
{
    …
    return(0);
}
```

The `envp` parameter to `main()` is actually optional and rarely used.

Examples can be found in
`~rchaney/Classes/cs333/src/argc_argv`

- **Every** C program must have a function called `main()`, which is the point where execution of the program starts.
- When the program is executed, the command line arguments (**the separate words parsed by the shell**) are made available via two arguments to the function `main()`.
- The shell is what does the meta-character evaluation. Your C program (probably) never sees the * or ? a user may place on the command line.

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Command Line Examples

A couple examples of command lines:

```
ls -l -a
```

Run the `ls` command, passing 2 command line arguments, `-l` and `-a`.

```
head -n 5 /etc/passwd
```

Run the `head` command, passing 2 command line argument2, `-n`. The `-n` command line argument has an option, the 5.
The second command line argument is the file name `/etc/passwd`.

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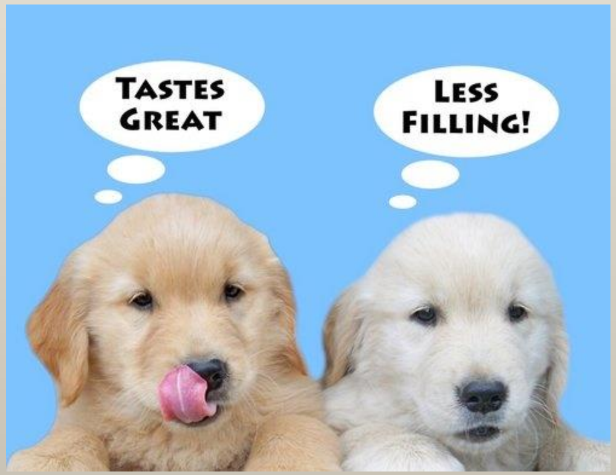
It’s really by convention that we continue call them `argc` and `argv`.

We could call then *yin* and *yang* or *Coke* and *Pepsi*. Or *TastesGreat* and *LessFilling*.

But, we **will** continue to call them `argc` and `argv`.



- The first argument, `int argc`, indicates **how many** command-line arguments are on the command-line.
- The second argument, `char *argv[]`, is an **array of pointers** to the command-line arguments, each of which is a **null-terminated character string**.

`argv[0]` is (almost) always the name of the program.

```
for (i = 0; i < argc; i++)
{
   printf("\tThe value of argv[%d] is: %s\n", i, argv[i]);
}
```

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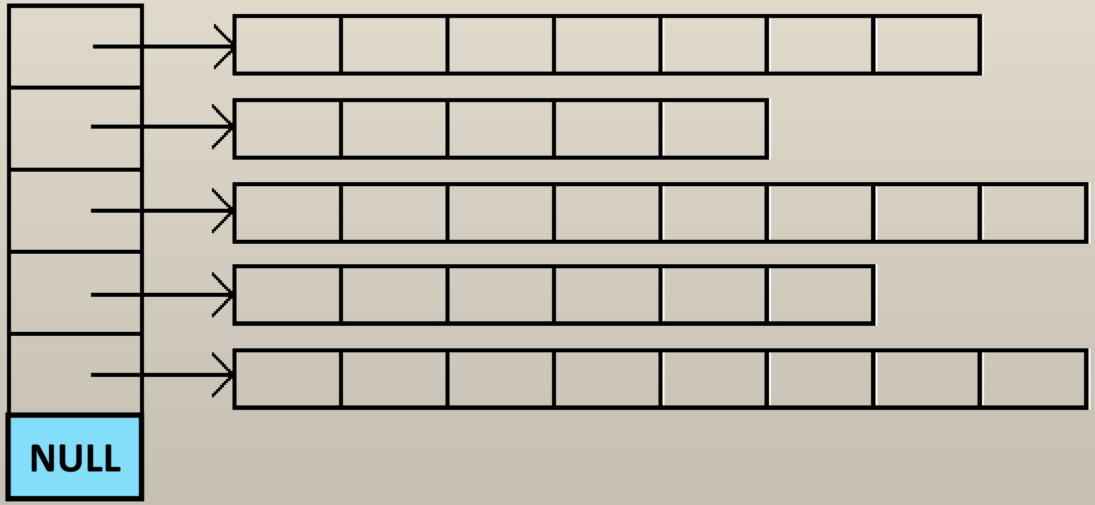
The **argv** parameter is exactly like a **ragged array**, except that it has an additional trailing **NULL** pointer at the end. Also known as a jagged array.

```
for (i = 1; NULL != argv[i]; i++)
{
   printf("\tThe value of argv[%d] is: %s\n", i, argv[i]);
}
```

The above code simply loops through `argv` and prints each item, except for `argv[0]`, the name of the program.



A regular array of C strings

a	b	c	**NULL**		
d	**NULL**				
e	f	g	h	i	**NULL**
j	k	l	**NULL**		
m	n	**NULL**			
o	p	q	r	**NULL**	
s	t	u	v	w	**NULL**

Every row has the same number of columns

A ragged array of C strings

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s	t	u	v	w	**NULL**

Each row has only the **necessary** number of columns

Environment Variables

Every UNIX process runs in a specific environment.

- An environment consists of **a table of environment variables**, each with an assigned value.
- When you log in certain login files are executed, which initialize the table holding the environment variables for the process.
- When this file passes the process to the shell, the table becomes accessible to the shell.
- When a parent process starts up a child process, the **child process is given a copy of the parent's environment table**.
- Environment variable names are generally given in **upper case,** by convention.

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Environment Variables

The environment with which a process starts is **inherited** from the shell/process in which it was started.

You can easily see what your shell environment is by issuing the command `printenv` or `env` from your shell.

Your environment variables contain a large number **interesting** and **useful** information.

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Environment Variables

```
// This is the one passed to main as char **envp
for (i = 0; NULL != envp[i]; i++)
{
   printf("\tThe value of envp[%d] is: %s\n", i, envp[i]);
}

////////////////////////////////////////////////////////////

// This is the newer, better, cooler way to handle environment
//  variables
#include <unistd.h> // POSIX stuff.
extern char **environ;

for (i = 0; NULL != environ[i]; i++)
{
   printf("\tThe value of environ[%d] is: %s\n", i, environ[i]);
}
```

Environment Variables

```
// When using envp (from main), this will not be
//  found in your environment. The envp data are static.
// If you use the environ external variable, you
//  will find these.
putenv("ENVIRONMENT_TEST=test_value");
putenv("HOME=test_value");

new_env = getenv("ENVIRONMENT_TEST");
new_env = getenv("HOME");
```

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Processing the Command Line

Processing the command line yourself can be challenging.

1. Are there command line options?
2. Do the options have arguments?
3. Can no-argument options be grouped?
4. Can the options be given in any order?
5. Are there things on the command line other than options with/without arguments?

Luckily, there's an app for that!

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The getopt() Library Function

```
#include <unistd.h>

int getopt(int argc
      , char * const argv[]
      , const char * optstring);

extern char *optarg;
extern int optind, opterr, optopt;
```

The getopt() function makes your life better.

These are magic global getopt() variables.

The getopt() library function **parses** the command-line.

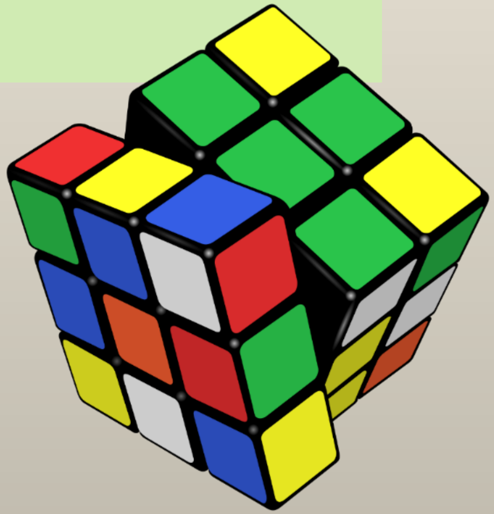
Its arguments argc and argv are the argument count and array as passed to the main() function on program invocation.

- An element of argv that starts with '-' (and is not exactly "-" or "--") is an option element.

- **`optstring`** is a string containing the legitimate option characters.
  - If such a character is **followed by a single colon**, the option **requires** an argument, so `getopt()` places a pointer to the following text in the same `argv`-element, or the text of the following `argv`-element, in `optarg`.
  - **Two colons** mean an option takes an **optional arg**; if there is text in the current `argv`-element (i.e., in the same word as the option name itself, for example, `"-oarg"`), then it is returned in `optarg`, otherwise `optarg` is set to zero.
- The variable **`optind`** is the index of the next element to be processed in `argv`. The system initializes this value to `1`.

- By default, `getopt()` **permutes** the contents of `argv` as it scans, so that eventually **all the non-options are at the end**.
- If `getopt()` does not recognize an option character, it prints an error message to `stderr`, stores the character in `optopt`, and returns `'?'`.

Permute: to rearrange.



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```
while ((opt = getopt(argc, argv, "os:i:")) != -1) {
  switch (opt) {
  case 'o':
    o_opt++; // Increment the variable each time the -o option is seen.
    printf("The -o option has been seen: %d\n", o_opt);
    break;
  case 's':
    strcpy(s_opt, optarg);
    printf("The -s option has been seen with argument %s\n", s_opt);
    break;
  case 'i':
    i_opt = (int) strtol(optarg, NULL, 10);
    printf("The -i option has been seen with argument %d\n", i_opt);
    break;
  default:
    printf("something strange has happened\n");
    break;
  }
}
```

The **colon** in the list of command line options means an argument is **required** for that option.

Magic variable that contains the string for the argument to a command line option.

Examples of **valid** command lines for this program are:

```
prog -s str -i17
prog -i5 -o -sStr
prog -osStr
```

Example of **invalid** command lines are:

```
prog -s
prog -s str -i
```

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What might remain on the command line after `getopt()` is done chewing on it?

Magic variable that contains the index from `argv` that is just **past** the last command line option (and argument) that was processed by `getopt()`.

```
if (optind < argc)
{
   int j;

   fprintf(stderr, "\nThis is what remains on the command line:\n");
   for(j = optind; j < argc; j++) {
     printf("\t%s\n", argv[j]);
   }
 }
```

Examples of other stuff on the command line are:

```
    prog -osStr stuff1 stuff2 moreStuff
    prog someStuff -s str -i17
    prog -i5 oddStuff -o -sStr
```

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Man Page for `getopt`

- The man page for `getopt` (`man 3 getopt`) not only contains an excellent description of how `getopt` works, but it also contains **a terrific example** of it use.
- I often start a new program by copying and pasting the example from the `getopt` man page into my code.
- Appendix B from TLPI also has a description for how `getopt` works.
- Learning to use `getopt` will make your life better and easier.