APT Session 4: C

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What to expect from this session

1. C.

Prerequisites

1. Install either GCC or LLVM/clang onto your computer. Most Unixes will have either/both installed by default, or as easy-to-install packages.

Prerequisites (Windows)

Windows users may find these instructions (courtesy of Sam White) useful:

1. Download the MinGW web installer.
2. Launch the installer, hit 'Install', then 'Continue' (leave the installation directory as the default, `C:\MinGW`). The installer will now download the files necessary. Once complete, hit 'Continue'.
3. The MinGW Installation Manager will now launch. Right-click 'mingw32-base' and select 'Mark for Installation'. Now, select 'Apply Changes' from the 'Installation' menu.
4. Hit 'Apply'. MinGW will now download and install the base package. This may take a minute or two. Once finished, you can close both windows. MinGW is now installed.
5. You can now find gcc in `C:\MinGW\bin`. You should add this directory to your PATH to make development easier.

Prerequisites (OS X)

OS X users may find these instructions (courtesy of Sam White) useful:

- If XCode is already installed, gcc can be installed by selecting `Command Line Tools` from Xcode Menu > Preferences > Downloads.
- Depending on your OS X version, you may also be able to install gcc without installing XCode by executing `xcode-select --install`.
- If you don't want to install XCode you can Download the command line tools from the Apple Developer website (registration, albeit free, required).

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- C++ is a separate language that adds many extra things to C; too complex for my tastes.
- C is still actively (if slowly) developed: new versions in ’99 and ’11. We will use C99.

The basics

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Other useful things to know:

- The main method in C is `int main(int argc, char **argv)`; the return value is returned to the shell. `return 0;` means 'I finished successfully'.
- `#include <stdio.h>` is similar to a Java import. It brings the `printf` function which prints a string to screen into scope.

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Exercises:

1. Write a program which prints out `Hello world!` in C. Put it in a file `hello.c` and compile it with `gcc -Wall --std=c99 hello.c`. This will produce an `a.out` or `a.exe` file which can then be run.

Basic types

- C has some similar basic types to Java: `int` and `char`.
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Other useful things to know:

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Exercises:

1 Assign the string `Hello world!` to a variable of type `char *` then print out the contents of the variable.

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- Pointers can be changed to other memory addresses.
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- e.g. if we have a variable `v` pointing to a `char *` array, we can access the first character either by explicit *dereferencing* with `*v` or using array syntax `v[0]` (the two are equivalent).
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Exercises:

1 Assign the string `Hello world!` to a variable of type `char *` then print out each character of the string on a new line.

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- C 'strings' are a pointer to a NUL-terminated region of memory. i.e. a sequence (of unknown length) of characters finishing with a char of value `0`. `strlen` manually walks the string each time!

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Exercises:

1. Print out all the command-line arguments passed to your program. What is the first parameter?
2. Print out all the command-line arguments passed to your program along with the length of the arguments.

Functions

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Exercises:

1. Write a ROT13 function which takes in a single `char` and returns its ROT13 equivalent. Test it with these cases `rot13('a')` $\triangleq$ `'n'` and `rot13('n')` $\triangleq$ `'a'`. You may assume only lower and upper case characters a–zA–Z will be passed.
2. Print out all command line arguments passed to your program after being ROT13ed.

Memory

- Memory is allocated in `n` bytes with `malloc(n)`. This returns `void *`, which can be cast to any pointer type you want (e.g. `char * c = malloc(n)`).
- Free memory with `free(c)`.
- You're responsible for freeing memory you allocated.
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Exercises:

1. What file do you need to include for `malloc`?
2. Concatenate all the command line parameters passed to the program into one string in memory. Print out a ROT13 version of the string, then the original string afterwards. Make sure you account for line endings when allocating memory!

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Exercises:

1. Change your `rot13` function so that it leaves spaces, newlines (etc.) untouched (i.e. it only applies rot13 to a-zA-Z).
2. Read input from `stdin`, rot13 it, and print it to `stdout`.
3. What happens if you chain your program twice? i.e. `cat file | rot13_stdin | rot13_stdin`?

Post-session exercises

Try these (no particular order):

- You might find this 'C for Java programmer guide' useful.
- Writing insecure programs in C is easy: read a guide to secure programming in C (e.g. this).
- Some of the best written – despite, oddly, having few comments – C code can be found in Unix kernels.
  e.g. OpenBSD's kernel is a work of art.