

TTK4147 - Real-time Systems

Exercise 0 - Basic tools

September 2021

Remember to check in at the lab, <https://innsida.ntnu.no/checkin/room/3066>, to allow for easier infection control in the event of a Covid-19 infection on campus.

This exercise is created so that everybody can learn the basic tools we will use during this course. It is intended more as a tutorial, rather than an exercise and, you are not required to submit your results. The student assistants are in the lab to help you, not to check on your progress. The exercise is optional, but it is recommended that you complete it, to make sure you are prepared for the rest of the course.

If you have questions, please apply for a spot in the queue by filling out the form (using your ntnu-user) with your workstation number: <https://s.ntnu.no/rts>.

IT IS IMPORTANT THAT YOU BACK-UP YOUR DATA PRIOR TO LEAVING THE LAB, AND DELETE ANY FILES THAT YOU HAVE STORED LOCALLY. THE COMPUTERS MAY BE REINSTALLED AT ANY TIME, AND ALL FILES DELETED WITHOUT ANY NOTICE.

1 The GNU/Linux environment

The computers on the real-time lab have two different operation systems; Windows and Ubuntu. When the computer boots, a menu where you can select between these is presented and you should select “Ubuntu”.

1.1 Ubuntu

When Ubuntu has started you will get a login window. You should use “student” as the user name and “Sanntid15” as the password. If you don’t already know Ubuntu, you should play around with the user interface. You should be able to find the programs for the following tasks:

- Web browsing (Firefox)
- Office programs (Open Office)
- Editors (Gedit, Emacs, Vim, Nano, Kate)
- Command line interface (Terminal)
- File browsing (Nautilus)

1.2 Shell

Even if Ubuntu has a graphical user interface, there are still many operations that are easier, faster and/or necessary to do from a Command Line Interface (CLI). You can get a window with a CLI by starting the program Terminal. The CLI is provided by one of several shell programs, most widely used are `bash`, `csh` and `tcsh`. The GNU/Linux default is `bash`, and you can check what type of shell your environment uses with the following command:

```
$ echo $SHELL
```

The first `$`-sign above is there just to indicate that the following text is a command to be typed in the CLI. It should therefore not be written. Also remember to hit ENTER.

There are many other environment variables such as `$PATH` (where the shell searches for commands) and `$HOME` (the user home directory). In `bash` you can use the `env` and `export` commands to view and modify the environment variables. Find out more about `apropos`, `help`, `info`, and `man` by typing for instance:

```
$ man man
```

Hitting 'q' in `man` will exit the program.
Find out what the following commands do:

- `ls`
- `cd`
- `pwd`
- `cp`
- `mv`
- `rm`

Find a command that tells you the date and the time on the system.

1.3 Directories and files

Your home directory is `/home/student`. Since this directory is shared with other groups using the same computer you should create the following structure: `/home/student/gruppeXX/ex1/` using the command `mkdir`. A simple text-file can be created by using the `echo` command:

```
$ echo -n "I do really love" > test.txt
$ echo " TTK4147" >> test.txt
```

Try `du`, `file`, `cat` and `wc` on the file you just created:

```
$ du -h test.txt
$ file test.txt
$ cat test.txt
```

1.4 Shell-scripts

It is possible to create small programs, or scripts, that are executed by the shell. Create a file named `script.sh` containing the following:

```
#!/bin/bash
for i in $(seq 1 10); do
    echo "Hello world $i"
done
```

and execute it by typing

```
$ bash script.sh
```

or

```
$ chmod +x script.sh
$ ./script.sh
```

What does the command `chmod` and the comment on the first line of the script do?

1.5 Jobs

To see the programs running on the system you can use `top`, `jobs` and `ps`. Do this now. Execute the command `$ sleep 5`. Then try adding an `&` after the command. What happens? Try running `jobs` to examine running processes.

Start `sleep 5` again, and press `CTRL+C` while the process is running. Try again but use `CTRL-Z` instead. What is the difference between `CTRL+C` and `CTRL+Z`. What does the command `fg` do?

1.6 Editors

A programmer needs an editor to edit his code files. There are religious wars among programmers (and especially GNU/Linux programmers) about what is the best editor. We are not taking sides in this conflict, and you are free to use whatever editor you like. If you have no preference, and just want something that “just works”, then `gedit` will probably be your best choice, while `nano` is an easy to use command line editor. Others editors are: `emacs`, `vim`, `kate` and `ed`.

2 Programming

2.1 GCC

The first Linux C-program you should create in this course is “Hello world”. Use your editor to create the “Hello world” C-program shown below.

```
#include <stdio.h>
int main(int argc, char *argv[])
{
    printf("Hello world\n");
    return 0;
}
```

```
}
```

Store the file `hello.c` in the working directory created for this exercise. We will learn more about the GNU compiler tools in later exercises. For now, try to compile the program you just created with GCC:

```
$ gcc -o hello hello.c
```

and run the program with:

```
$ ./hello
```

2.2 Makefile

You should now create a more advanced program, inspect the following C-code and figure out what it does:

```
#include <stdio.h>

int main(int argc, char *argv[])
{
    while(argc--)
        printf ("%s\n",*argv++);
    return 0;
}
```

Create a file name `sort.c` containing the following:

```
#include <stdlib.h>

void sort(int count, char *array[])
{
    int x,y;
    char* holder;
    for(x = 1; x < count; x++)
        for(y = 1; y < count-1; y++)
            if( atoi(array[y]) > atoi(array[y+1]) ) {
                holder = array[y+1];
                array[y+1] = array[y];
                array[y] = holder;
            }
}
```

Make a separate file called `main.c` with a `main()` function, from which you call to the `sort()` function, in order to sort the arguments list, and then print out the results. An example of the main-file is:

```
#include <stdio.h>
#include "sort.h"

int main(int argc, char *argv[])
```

```

{
    int i;

    printf("Arguments before sort: ");

    for (i=1;i < argc;i++)
        printf("%s ",argv[i]);
    printf("\n");

    sort(argc,argv);

    printf("Arguments after sort: ");

    for (i=1;i < argc;i++)
        printf("%s ",argv[i]);
    printf("\n");

    return 0;
}

```

The sort.h file should only contain a declaration of the function:

```
void sort(int count, char *array[]);
```

You can compile the files by using:

```
$ gcc -o sort_args sort.c main.c
```

and run:

```
$ ./sort_args 34 2 919 34 42 51353
```

This is fine for smaller programs, but with larger programs and multiple files there is a problem: each time one of the files changes, all files are compiled again. A waste of computing resources! Instead, create the Makefile below. Make sure that there are TABs, not spaces in front of `gcc` and `rm`.

```

# program executable name
TARGET = sort_args

# compiler flags
CFLAGS = -g -Wall

# linker flags
LDFLAGS = -g

# list of sources
SOURCES = $(shell find -name "*.c")

# default rule, to compile everything
all: $(TARGET)

```

```
# define object files
OBJECTS = $(SOURCES:.c=.o)

# link programs
$(TARGET): $(OBJECTS)
    gcc $(LDFLAGS) -o $$ $^

# compile
%.o : %.c
    gcc $(CFLAGS) -c -o $$ $<

# cleaning
clean:
    rm -f $(TARGET) $(OBJECTS)
```

This Makefile can be used (with minor changes) for all Linux C programs we will develop in this course. It will compile and link all the source files in its folder. It will generate an executable that is named `sort_args`. To change this, edit the first line in the Makefile.

Build your program with the command `make`. Verify that the program is built correctly. Next, make some changes in either `sort.c` or `main.c`, and verify that only the changed files are re-compiled. You can also remove all generated files with the command `make clean`