

Operating Systems

Grado en Informática. Course 2020-2021

Lab assignment 0: Introduction to C programming language

To get acquainted with the C programming language we'll start to code a shell, coding of this shell will be continued in next lab assignments.

We'll start with a nearly empty shell, which is basically a loop that

- prints a *prompt*
- reads from the standard input a line of text which includes a command (with its arguments).
- stores this command in a list of commands that it has been given, each with its order number in a list we'll call the *historic* of commands.
- separates the command and its arguments
- processes the comand with its arguments

At this moment this *shell* has to understand only the following commands. In the next lab assignments we will be COMPLETING this shell: we BUILD lab assignment 1 ON the code of lab assignment 0, lab assignment 2 ON the code of lab assignment 1 and so on

authors [-l|-n] Prints the names and logins of the program authors. **authors -l** prints only the logins and **authors -n** prints only the names

getpid Prints the pid of the process executing the shell.

getppid Prints the pid of the shell's parent process.

pwd prints the shell's current workin directory.(using *getcwd*)

chdir [direct] Changes the current working directory of the shell to *direct* (using the *chdir* system call). When invoked without auguments it behaves exactly as the *pwd* command.

date Prints the current date in the format DD/MM/YYYY.

time Prints the current time in the format hh:mm:ss

historic [-c|-N|-rN] Shows/clears the *historic* of commands executed by this shell or repeats one command. In order to do this, a list to store all the commands input to the shell must be implemented. *historic -c* clears the historic, that's to say, empties the list

- **historic** Prints all the comands input with their order number
- **historic -c** Clears (empties) the list of *historic* commands

- `historic -N` Prints the first N commands
- `historic -rN` Repeats command number N

Example:

```
* ) pwd
/home/antonio/Practicas
* ) getppid
11562
* ) getpid
11581
* ) chdir /root
Cannot change dir /root: permission denied
* ) chdir pru.c
Cannot change dir pru.c: not a directory
* ) historic
0->pwd
1->getppid
2->getpid
3->chdir /root
4->chdir pru.c
6->historic
* ) historic -2
0->pwd
1->getppid
2->getpid
* ) historic -r3
chdir /root
Cannot change dir /root: permission denied
```

Students are free to decide whether *historic* starts numbering commands at 0 or at 1. Hypothetically, there's a scenario where trying to repeat a *historic* command could yield an infinite loop or a stack overflow (depending on how it is coded), so students may choose to not store calls to *historic* itself in the historic list if they want so (such scenario would be `historic -r9` in the previous example) (See the *NOTES ON LIST IMPLEMENTATIONS* at the end of this document)

quit Ends the shell

end Ends the shell

exit Ends the shell

- This program should compile cleanly (produce no warnings even when compiling with `gcc -Wall`)

- **NO RUNTIME ERROR WILL BE ALLOWED** (segmentation, bus error ...), unless where explicitly specified. **Programs with runtime errors will yield no score.**
- This program can have no memory leaks (please use valgrind to check)
- When the program cannot perform its task (for whatever reason, for example, trying to change the current working directory to a directory that does not exist or that shell has not enough privileges) it should inform the user, giving an appropriate description of the error such as the one given by *strerror()*, *perror()*, `sys_errlist[errno]` ...
- All input and output is done through the standard input and output
- Should any doubts as to how the shell must behave, please check the executable files provided

Information on the system calls and library functions needed to code this program is available through man: (*printf*, *gets*, *read*, *write*, *exit*, *getpid*, *getppid*, *getcwd*, *chdir*, *time* ...).

WORK SUBMISSION

- Work must be done in pairs.
- The source code will be submitted to the subversion repository under a directory named **P0**
- The name of the main program file will be `p0.c`. Program must be able to be compiled with `gcc p0.c` Alternatively a **Makefile** can be supplied so that the program can be compiled with just `make`
- Only one of the members of the workgroup will submit the source code. The names and logins of all the members of the group should be in the source code of the main program (at the top of the file)

DEADLINE: OCTOBER THE 9TH. THIS LAB ASSIGNMENT WILL YIELD NO SCORE, NEITHER WILL IT BE EVALUATED. HOWEVER ALL THE CODE FOR THIS ASSIGNMENT MUST BE REUTILIZED FOR THE FOLLOWING ASSIGNMENTS. THIS ASSIGNMENT WILL ALSO HELP GET ACQUAINTED WITH THE **SVN** REPOSITORY, NEEDED FOR THE CORRECT SUBMISSION OF ALL OF THE FOLLOWING LAB ASSIGNMENTS (FROM THE NEXT ASSIGNMENT ON, WORK WRONGLY SUBMITTED WILL NO BE EVALUATED)

CLUES

A shell is basically a loop

```
while (!terminado){
```

```

    imprimirPrompt();
    leerEntrada();
    procesarEntrada();
}

```

imprimirPrompt() and *leerEntrada()* can be as simple as calls to **printf** y **gets** (there's a reason why *fgets()* should be used instead of *gets()*)

The first step when processing the input string is splitting it into words. For this, the **strtok** library function comes in handy. Please notice that **strtok** nor allocates memory neither does copy strings, it just breaks the input string by inserting end of string ('\0') characters. The following function splits the string pointed by *cadena* (supposedly not null) into a NULL terminated array of pointers (*trozos*). The function returns the number of words that were in *cadena*

```

int TrocearCadena(char * cadena, char * trozos[])
{
    int i=1;

    if ((trozos[0]=strtok(cadena, " \n\t"))==NULL)
        return 0;
    while ((trozos[i]=strtok(NULL, " \n\t"))!=NULL)
        i++;
    return i;
}

```

NOTES ON LIST IMPLEMENTATION

- the implementations of list should consist of the data types and the access functions. All access to the list should be done using the aforementioned access functions.
- four list implementations are to be considered:
 - 0) **linked list**: The list is composed of dynamically allocated nodes. Each node has some item of information and a pointer to the following node. The list itself is a pointer to the first node, when the list is empty this pointer is NULL, so creating the list is assigning NULL to the list pointer, thus the functions **CreateList**, **InsertElement** and **RemoveElement** must receive the list by reference as they may have (case of inserting or removing the first element) to modify the list.
 - 1) **linked list with head node**: Similar to the linked list except that the list itself is a pointer to an *empty* (with no information) first node. Creating the list is allocating this first element (head

node). `CreateList` must receive the list by reference whereas `InsertElement` and `RemoveElement` can receive the list by value.

- 2) **array:** Elements in the list are stored in a statically allocated array of nodes, so the list type is a pointer to a structure containing the array of nodes and optionally one or more integers (depending on the implementation: `nextin` and `nextout` indexes, `counter` ...). For the purpose of this lab assignment, we can assume the array dimension to be 4096 (which should be declared a named constant, and thus easily modifiable).
- 3) **array of pointers;** The list is an array (statically allocated) of pointers. Each pointer points to one element in the list which is allocated dynamically. For the purpose of this lab assignment we can assume this statically allocated array dimension to be 4096, which should be declared a named constant, and thus easily modifiable. To implement the list with this array we can use either a NULL terminated array or we can use additional integers.

- **EACH WORKGROUP MUST DO THE LIST IMPLEMENTATION RESULTING FROM THE FOLLOWING PROCEDURE:** Add the two last digits of the D.N.I. of the workgroup components and calculate its module 4, that will yield the implementation to use. Should one (or more) component of the workgroup have no D.N.I., then the ascii code of its capitalized family name initial should be used instead.

- **example 1:** workgroup components D.N.I.s are 55555581 and 55555507, so the implementation to use will be given by $(81 + 07) \% 4$, so this group will have to use implementation 0, **linked list**
- **example 2:** workgroup componets are D.N.I. 55555581 and Donald Trump (who, as of now, does not have a valid D.N.I., to the best of our knowledge) so, as the ascii code for the **T** is 84, this group would have to use implementation $(81 + 84) \% 4 = 1$. **linked list with head node**