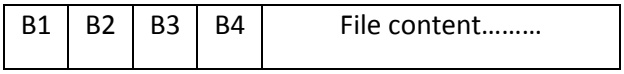
Distributed Programming

Test on Network Programming of July 21, 2017 Time: 2 hours 10 minutes

The exam material is located in the folder "`exam_dp_jul2017`" within your home directory, which is referred to as `$ROOT` in this text.
For your convenience, the exam material already contains a skeleton of the C files you have to write (in the "`$ROOT/source`" folder). It is **HIGHLY RECOMMENDED** that you start writing your code by filling these files **without moving them** and that you read carefully and completely this text before starting your work!
The exam consists of writing a server and a client that exchange files represented using a format very similar to the one developed for the lab exercise 2.3 (file transfer), but simpler. More precisely, when a connection is established, the client **sends** a file to the server using the following format:



where bytes B1 B2 B3 B4 in the figure are a 32-bit unsigned integer in network byte order that represents the number of bytes of the file. As it can be seen in the above figure, the bytes of the file follow these four bytes. While receiving the file, the server performs a transformation on the bytes of the file and sends the transformed file back to the client, using the same connection and the same data format. In the meanwhile, the client receives the transformed file. When the transformed file has been transferred completely, the connection is closed gracefully. In order to maximize performance and enable the handling of large files, the client starts receiving the transformed file immediately, instead of starting reception after having finished to send the whole file. Similarly, the server is required to buffer no more than 10000 bytes (i.e. it cannot read more than 10000 bytes without sending anything back to the client).

Part 1 (mandatory to pass the exam, max 6 points)
Create a server that implements the protocol described above. Of course, you can exploit your solution of Lab exercise 2.3 for this purpose. The server must listen to the port specified as its first argument on the command line (as a decimal number), on all the available interfaces. The second argument on the command line, instead, is an ASCII string that specifies the transformation to be applied to each received file: each character of the received file that matches one of the characters of this string has to be replaced by an ASCII asterisk character (*), while all other bytes are left unaltered.
The server has to be written using the main C template that is under the directory `$ROOT/source/server1` and the C file(s) of the server program must all be stored in the directory `$ROOT/source/server1`, except for common files (e.g. the ones by Stevens) that you want to re-use in the other programs you have to develop in this test, which you have to put into the directory `$ROOT/source` (remember that if you want to include some of these files in your sources you have to specify the "`..`" path).
In order to test your server, you can run the command

```
./test.sh
```

from the `$ROOT` directory. Note that this test program also runs other tests (for the next parts). It will indicate if at least the mandatory tests have been passed.

Part 2 (max 6 points)
Create a client that implements the protocol described above. Of course, you can exploit your solution of Lab exercise 2.3 for this purpose. The client receives the IPv4 address (in dotted decimal notation) and the port number (in decimal notation) of the server to connect to as the first and second argument on the command line respectively, the name of the file to send as the third argument, and the name to be given to the received transformed file as the fourth argument. The file to be sent must be present in the local directory of the client otherwise the client has to terminate before connecting to the server. The transformed file received by the client must be stored in the same directory. If a file with the same name is already present, it must be overwritten.
Suggestion: it is easier to write a concurrent client that uses two processes: the parent sends the file while the child receives the response and stores the transformed file. The parent waits for the termination of the child before exiting.
The C file(s) of the client program must all be written in the directory `$ROOT/source/client1`, except for common files that, as already said, have to be stored in the directory `$ROOT/source`.
The test command indicated for Part 1 will also try to test Part 2.

Part 3 (max 4 points)
Write a new version of the server developed in Part 1 (named `server2`) that behaves as `server1` but

- it is a concurrent version of the server that can serve at least 3 clients concurrently (for `server1` there was no requirement about concurrency).
- it closes the connection with the client if the client has not finished sending the advertised number of bytes and the server receives no bytes from the client for 3 seconds (`server1` was not required to do so).

The C file(s) of the `server2` program must all be written in the directory `$ROOT/source/server2`, except for common files that, as already said, have to be stored in the directory `$ROOT/source`.
The test command indicated for Part 1 will also try to test Part 3.

Further Instructions (common for all parts)
In order to pass the exam, it is enough to implement a `server1` that correctly responds to a file upload according to the new protocol, **or** to implement a `client1` and a `server1` that can interact with each other as expected (i.e. at least they can transfer forth and back a small file correctly).
Your solutions will be considered valid **if and only if** they can be compiled by the following commands issued from the `source` folder (the skeletons that have been provided already compile with these commands; do not move them, just fill them!):

```
gcc -o socket_server1 server1/*.c *.c -Iserver1 -lpthread -lm
```

```
gcc -o socket_client1 client1/*.c *.c –Iclient1 -lpthread -lm

gcc -o socket_server2 server2/*.c *.c -Iserver2 -lpthread -lm
```

For your convenience, the test program also checks that your solutions can be compiled with the above commands.
Note that all the files that are necessary to compile your programs must be included in the source directory (e.g. it is possible to use files from the book by Stevens, but these files need to be included by you).
All the produced source files (`client1`, `server1`, `server2`, and common files) must be included in a single zip archive created with the following bash command (run from the `$ROOT` directory):

```
./makezip.sh
```

At the end of the test, the zip file with your solution must be left where it has been created by the zip command.

Important: Check that the zip file has been created correctly by extracting it to an empty directory, checking its contents, and checking that the compilation commands are executed with success (or that the test program works).

Warning: the last 10 minutes of the test MUST be used to prepare the zip archive and to check it (and fix any problems). If you fail to produce a valid zip file in the last 10 minutes your exam will be considered failed!

The evaluation of your work will be based on the provided tests but also other aspects of your program (e.g. robustness) will be evaluated. Then, passing all tests does not necessarily imply getting the highest score. When developing your code, pay attention to making a good program, not just making a program that passes the tests provided here.

For your convenience, the text of Lab exercise 2.3 is reported in the next pages of this file.

Exercise 2.3 (iterative TCP server)

Develop a TCP server (listening to the port specified as first parameter of the command line) accepting file transfer requests from clients and sending the requested file.

Develop a client that can connect to a TCP server (to the address and port number specified as first and second command-line parameters, respectively), to request files, and store them locally. File names to be requested must be provided to the client using the standard input, one per line. Every requested file must be saved locally and the client must print a message to the standard output about the performed file transfer, with file name, size and timestamp of last modification.

The protocol for file transfer works as follows: to request a file the client sends to the server the three ASCII characters “GET” followed by the ASCII space character and the ASCII characters of the file name, terminated by the ASCII carriage return (CR) and line feed (LF):

G	E	T		…filename…	CR	LF

(Note: the command includes a total of 6 characters plus the characters of the file name). The server replies by sending:

+	O	K	CR	LF	B1	B2	B3	B4	T1	T2	T3	T4	File content……

Note that this message is composed of 5 characters followed by the number of bytes of the requested file (a 32-bit unsigned integer in network byte order - bytes B1 B2 B3 B4 in the figure), then by the timestamp of the last file modification (Unix time, i.e. number of seconds since the start of epoch, represented as a 32-bit unsigned integer in network byte order - bytes T1 T2 T3 T4 in the figure) and then by the bytes of the requested file.

To obtain the timestamp of the last file modification of the file, refer to the syscalls *stat or* f*stat.*

The client can request more files by sending many GET commands. When it intends to terminate the communication it sends:

Q	U	I	T	CR	LF

(6 characters) and then it closes the communication channel.

In case of error (e.g. illegal command, non-existing file) the server always replies with:

-	E	R	R	CR	LF

(6 characters) and then it closes the communication channel with the client.

Save the client into a directory different from the one where the server is located. Name the client directory as the client program name.

Try to connect your client with the server included in the provided lab material, and the client included in the provided lab material with your server for testing interoperability (note that the executable files are provided for both 32bit and 64bit architectures. Files with the suffix _32 are compiled for and run on 32bit Linux systems. Files without that suffix are for 64bit systems. Labinf computers are 64bit systems). If fixes are needed in your client or server, make sure that your client and server can communicate correctly with each other after the modifications. Finally you should have a client and a server that can communicate with each other and that can interoperate with the client and the server provided in the lab material.

Try the transfer of a large binary file (100MB) and check that the received copy of the file is identical to the original one (using diff) and that the implementation you developed is efficient in transferring the file in terms of transfer time.

While a connection is active try to activate a second client against the same server.

Try to activate on the same node a second instance of the server on the same port.

Try to connect the client to a non-reachable address.

Try to connect the client to an existing address but on a port the server is not listening to.

Try to de-activate the server (by pressing ^C in its window) while a client is connected.