Systems programming

Week 3 – Lab 5

ZeroMQ and Internet sockets

Internet domain sockets allow the communication of programs running in multiple computers using the Internet.

The way to establish communication using Internet domain sockets is similar with the use of datagram sockets. The main different is the way the socket addresses (identification of the recipient socket) are defined.

For two processes to communicate with Internet domain sockets it is necessary to create one socket on each program: each communication participant should create a socket.

To receive data from another remote socket it is necessary to assign/bind an address. This can be done explicitly with the bind function or implicitly by the **sendto**. In internet domain sockets, after sending data with the **sendto** function, such socket is ready to receive messages. In this case the recipient of the message will get an address that was implicitly assigned/bind during the **sendto**.

1 Internet domain sockets addresses

ZeroMQ Unix domain socket use addresses composed of a string (file path). This is enough to allow processes in the same computer to use (bind and connect) those sockets, but for Internet communication a more complex address is needed.

In Internet domain sockets addresses are composed of two distinct parts:

- the IP address (for instance 146.193.41.15)
- the port (for instance 80)

by knowing the address of the server and the port of the program any other client on the internet can connect to it.

1.1 Internet domain TCP addresses

The generic representation of a ZermoMQ TCP Internet domain socket is **tcp://<addr>:<port> .** Depending whether this address is being used in the server (in

the bind) or in the clients (doing connect), the **addr** part can change, while the port should be the same (for client and server).

The port should be unique on the computer running the server application and, for regular applications, usually ranges between 1024 and 49151. In our example this value is defined as 5555.

When performing the connect, the client should use one of the numeric addresses (using the **xxx.xxx.xxx.xxx** notation) assigned to the server computer on the **addr** part.

NI the bind, the server can use a wildcard (*****) in the **addr** part, meaning that if the computer running the server has several network cards, with multiple addresses, the server will be accessible in any of those addresses. If the server application is supposed to be accesses in a specific address , the **addr** part should contain it.

If the client uses the same address the server used in the bind (or the server used the wildcard) a connection will be established unless there is a network outrage. If the addresses do not match an error will be returned.

1.2 Available addresses in computers

Computers connected to the Internet can have multiple addresses.

One of such addresses is the **127.0.0.1**. All computers have this address and, if used in a client, the program will try to communicate with a server running on the same computer.

To accept remote connections it is necessary to tell the clients what are the available addresses of the computer that runs the server. To know such addresses there are a some commands to be executed on the server computer:

- in Linux – **ip** a or **ifconfig**
- MAC OS X – **ifconfig**
- Windows – **ipconfig**

These command should be executed in a terminal or command prompt window and will produce the following outputs.

ip a

```
1: lo: <LOOPBACK,UP,LOWER_UP> mtu 65536 . . .  qlen 1000
. . . .
    inet 127.0.0.1/8 scope host lo
. . . .
2: enp4s0f0: <BROADCAST,MULTICAST,UP,LOWER_UP> . . . qlen 1000
. . . .
    inet 146.193.41.15/24 brd 146.193.41.255 . . .  enp4s0f0
. . . .
```

ip a (Linux / WSL)

```
lo0: flags=8049<UP,LOOPBACK,RUNNING,MULTICAST> mtu 16384
. . . .
   inet 127.0.0.1 netmask 0xff000000
. . . .
en0: flags=8863<UP,. . . . > mtu 1500
. . . .
   inet 146.193.41.40 netmask 0xffffff00 broadcast 146.193.41.255
. . . .
   status: active
```

ipconfig

```
Windows IP Configuration
Ethernet adapter vEthernet (WSL):
IPv4 Address. . . . . . . . . . . : 172.26.0.1
Ethernet adapter Ethernet 4:
IPv4 Address. . . . . . . . . . . : 192.168.56.1
Wireless LAN adapter Wi-Fi:
IPv4 Address. . . . . . . . . . . : 194.210.228.171
```

For different computers, the number of available addresses may change but the relevant ones are identified as **inet xxx.xxx.xxx.xxx** (in Linux/MAC OS X /WSL) or **Ipv4 Adress xxx.xxx.xxx.xxx** in windows.

Not all addresses are accessible remotely because of network or firewall configurations.

2 Exercise 1 - Remote control on the Internet

Modify the **exercise 3 from Lab 3** (provided files) so that the server and clients run on different computers using ZeroMQ TCP sockets.

3 Exercise 2 - Remote display client

Extend the solution of **exercise 2** with a new type of client (**remote-display-client.c**) that shows on the screen the same information as the server. Multiple instances of this new client can run at the same time and all will replicate the screen of the server.

Whenever the server updates its screen (because a character moved) the updates should also be sent to all **remote-display-clients**. These new clients should receive messages with the screen position to be updated and the corresponding character.

The skeleton of this new client is also provided as the file **remote-display-client.c**.

4 Exercise 3 – payper view

Modify the server and the **remote-display-client.c** to guarantees that only authorized **remote-display-clients** will be able to show the characters movements, as in the pay per view boxing combats (i.e. only those clients that payed a ticket will be able to see the live combat).

5 Sigma computer

Sigma is a server hosted at Técnico that can be remotely accessed by student. It runs Linux and is a shared memory multiprocessor computer, with most of the necessary tools (compilers, libraries, …)

Student can access this computer in two different ways to:

- remote terminal – to execute commands
- file transfer – to download and upload files

This service may need to be activated in the DSI self-service:

https://selfservice.dsi.tecnico.ulisboa.pt/

5.1 sigma remote terminal

To access a command line in sigma it is necessary to use the ssh protocol.

In linux or MAC os X the students only need to issue the follwoig command in a terminal:

```
ssh istXXXXX@sigma.ist.utl.pt
```

and replace **XXXXX** by the correct istID.

After connecting student should type the password. If correct, students can now start to use all the installed programs and compilers

In windows it is necessary to install a ssh client such as:

- putty - https://www.putty.org/

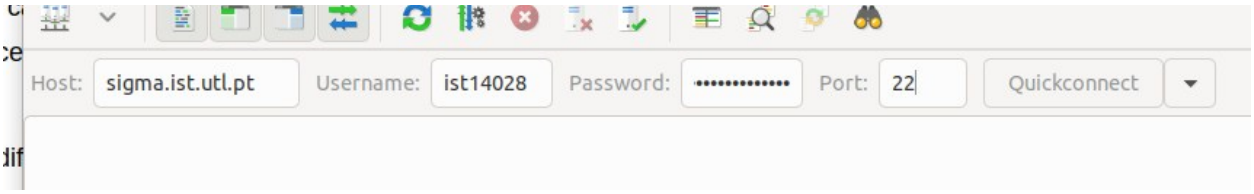
5.2 file transfer

To transfer files to/from the sigma it is necessary to use a **sftp** client.

The best **sftp** client is **filezilla** that is available for Windows, Linux and MAC OS X:

- https://filezilla-project.org/

to connect students can use the **quickconnect** as illustrated:



After connection students can transfer files by dragging files in the presented windows.